A National Program of Research for

ENVIRONMENTAL QUALITY-

Pollution in Relation to Agriculture and Forestry

Prepared by

A JOINT TASK FORCE OF THE
U. S. DEPARTMENT OF AGRICULTURE
AND THE STATE UNIVERSITIES
AND LAND GRANT COLLEGES

United States
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Agriculture

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FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The task force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The task force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the task force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It should not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

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This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D.C. 20250.

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INTRODUCTION

Quality of the environment, a major objective of all agricultural and forestry research programs, is of vital concern to every segment of human society. Oddly, the concept of environmental quality is so recent that there is no widely accepted definition of the term. Yet, the absence of quality is easily recognized. In city or countryside, on land, air, or water -- everywhere we face increasing pollution.

Definition of the Problem

Environmental pollution is the unfavorable alteration of our surroundings, including the life that abounds there, through direct or indirect effects of changes in energy patterns, radiation levels, chemical and physical constitution, and abundances of organisms. Many pollutants, such as pollens in the air and mineral plant nutrients in our waters, occur naturally. Man's actions have increased such pollution in many instances. He has also introduced new pollutants, such as exotic chemicals, into our environment.

Most programs concerned with environmental quality are aimed at preventing deterioration of or at restoring our environment to a former quality. Increasingly, these programs will also be concerned with enhancing quality of the environment.

A National Program

This report presents a national program of research on pollution in relation to agriculture and forestry within the framework of A National Program of Research for Agriculture, which, in 1966, aggregated agricultural and forestry research into broad problem areas and recommended attainment levels for 1972 and 1977.

The Agricultural Research Planning Committee (ARPC), including members from USDA, the State agricultural experiment stations (SAES), and the educational institutions making up the Association of State Colleges and University Forestry Research Organizations (ASCURFO), identified pollution research as one of the areas which should be intensively reviewed as a necessary step toward implementation of long-range plans. A research task force was set up to develop such a comprehensive and coordinated research program. This report is the product of this effort. Other task forces are developing similar analyses for other subject matter areas.

Missions of Relationship to Agriculture

During its initial planning stages, the task force recognized the close relationship between environmental quality and the missions of agriculture: "Income and Abundance," "Dimensions for Living," "Growing Nations -- New Markets," and "Communities of Tomorrow." It is imperative to maintain the quality of environment in rural America in order to achieve these missions. The selected examples that follow illustrate how pollution affects the attainment of these missions.

Pollution is a major cost greatly affecting agricultural "Income and Abundance." For example, the very high cost of waste disposal from livestock and poultry production units and processing plants; pulp and paper mills; and vegetable, fruit and dairy and meat processing plants must be borne by the entrepreneur, the public, or both. These costs are increasing. Current and historic methods of waste disposal are not adequate.

Pollution is also an expensive burden on agriculture's missions "Dimensions for Living" and "Growing Nations -- New Markets." Safety and wholesomeness of our food supply -- equally essential to American consumers and to increasing foreign markets for our food products -- are important components of these missions. Identifying research needed to prevent pollutants from contaminating our foods is in part the responsibility of this task force. It is worth noting here that we enjoy the world's most wholesome food supply -- a blessing due, in part, to the vigilance of farmers, industry, and regulatory officials.

Pollution of the land and communities of rural America must be controlled or eliminated in order to achieve the purposes of the "Communities of Tomorrow" mission. Accelerated problem-solving research to develop effective, economic means to reduce the fact and the threat of pollution of our rural lands and their associated air and water is essential to improving the quality of the environment. There are few areas of equal urgency for expanded research. The quality of the rural environment must be suitable for farming, forestry, industry, recreation, and gracious living for all who live in the country and for all who visit it.

Scope of the Report

This report projects a proposed "pollution research package" for agricultural and forestry research. It is concerned with researchable problems arising from all pollutants affecting farms, forests, and rural areas. It is equally concerned with pollutants originating in farm, forest, and rural areas--those that may affect our environment generally. Moreover, it is concerned with related problems directly resulting from the processing of farm and forest products and those stemming from chemical and other farm supply industries.

The task force considered research needed for the development and application of objective standards for managing the environment. It recognized the need for all agencies, as they carry out their research programs, to use a systems analysis approach. Stated simply, the systems approach is organized common sense plus modern mathematical tools. It consists of defining, limiting, and analyzing problems; devising mathematical models; obtaining reliable data; investigating the results of alternative actions via the models; scheduling research and development. Above all, the systems approach requires a deep understanding of the practical aspects of pollution. It requires learning by doing and allows adjustments as the program progresses. It can prevent crises and emotions from influencing decisions of a technical-economic nature.

Research on pollution in relation to agriculture and forestry requires the development and assembly of instrumentation and equipment with special capabilities. Instruments are needed for identification of the kind and magnitude of the components which are polluting the environment. Accuracy of instruments must be compatible with the anticipated degree of error of the research as well as consistent with the accuracy with which the pollution abatement system itself can be designed. The development or assembly of instrumentation needs for this research is considered to be a necessary part of the research program although instrumentation per se may not be indicated in the problem statement.

SUMMARY OF POLLUTION PROBLEMS

Agricultural and forestry research are concerned with the greatest portion of the land and water areas of this country, and with such things as ornamental and shade plants and soils that contribute to the attractiveness and stability of urban and suburban areas. Practices that result in prevention or control at the source offer unique opportunities for reducing pollution. <u>Appropriately, a considerable amount of agriculture and forestry research is directed toward pollution control</u>. <u>In addition, a great deal of such research having a principal purpose other than the pollution control is nonetheless directly relevant to such control</u>.

Examples are:

** Research on watershed management affords information about ways to reduce erosion and, correspondingly, to reduce sediment-borne phosphorous and other chemicals.

** Research on safe, effective methods of controlling such pests as ragweeds and mosquitoes contributes to the reduction of infectious agents and allergens in the environment. The use of biological controls such as the sterilization of male screw-worm flies in lieu of pesticides results in the reduction of toxic chemicals in soil, water, air, and non-target organisms.

** Research on controlling forest fires contributes to the reduction of smoke and particulate matter in the atmosphere and to the reduction of sediment resulting from erosion of burned-over land.

** Research on better cultural and conservation practices and on the improvement of plants results in better retention of soil under or protected by vegetation, more efficient and complete use of plant nutrients, and improved urban and suburban cycling of airborne gases associated with life processes.

** Research on improving livestock and poultry production and management systems and on soil and water results in improved manure handling and disposal techniques, minimizing odors, reducing fly populations, reducing plant nutrient or infectious agent-bearing runoff from animal confinement areas, and enhances soil fertility and quality of produce grown thereon.

** Research on new and improved food and fiber products results in increased byproduct recovery, improved treatment and use of processing plant effluents, and more readily processed raw materials.

Many more could be cited.

A large amount of research by nonagricultural agencies on control of air pollution will help with problems of agriculture and forestry. Furthermore, in the areas of heat, noise, and radionuclides most research is, and will be, nonagricultural.

The Task Force strongly urges research administrators and other task forces concerned with Research Problem Areas involving pollution and pollution-related research to give full consideration to their pollution abatement and control implications.

One important limiting factor in pollution control and abatement is the inadequacy of data describing the polluted environment. Systems of monitoring need to be designed and tested that will identify the kind and magnitude of pollution elements within the limits of accuracy required for the design of the abatement systems. The operation of the monitoring system is not considered to be a research function, but the design of the system is appropriate for research.

Pollution problems are defined under ten general headings in this report. The Task Force considered problems relevant to more than one of these areas, and the socioeconomic aspects of each of them. In addition to the individual pollutant or vehicle for pollutant transport sections, others in this report deal with systems analysis and socioeconomics of agricultural and forestry pollution. The need for interdisciplinary and aggregative problem procedures is evident in all of the sections, but is especially highlighted in the systems analysis discussion.

Animal and Domestic Wastes

Pollution arises from animal excreta and animal production operations. Such pollution may affect air, water, soil, and various life forms. It has been associated with oxygen depletion, excessive nutrient loads and unsightly appearances in streams; infectious agents that affect man and animals; obnoxious odors; toxic gases; insects; and dusts. The magnitude of the problem may be illustrated by the biochemical oxygen demand (BOD) of manure produced from agricultural livestock and poultry in the United States, which is estimated to be ten times that of the sewage produced by the human population. Costs of controlling this pollution may adversely affect the animal economy.

Rural domestic wastes refer to both human excreta and to the wastes arising from food preparation and other byproducts of living. It is estimated that only one-fourth of the 17 million rural homes have water piped into the homes. Pollution control in rural water systems is closely related to the disposal of domestic wastes. Potable water is essential for human health

and maintenace of agricultural product quality as related to either the animal's drinking water or to the cleansing of product and product handling equipment.

Processing Wastes

Processing of agricultural commodities into food products, textiles, leather, feed, and industrial products and of wood into pulp and paper products inevitably results in loss of organic matter. This loss may range from a small amount up to 25 percent or more of the raw material undergoing processing. The adverse effects of these wastes are proportional to their organic load imposed on receiving waters. At the present level of waste treatment, the trend is such that organic industrial wastes will become a greater source of river pollution than municipal sewage.

Approximately 500 million acres of forest land are managed under multiple use programs for timber production. Of the 10 billion cubic feet harvested, 30 percent is harvested as pulpwood and serves as the raw material for America's wood pulp and paper industry. The liquid effluent generated each day in paper production, after treatment, is six billion gallons containing five million pounds of BOD. This is equivalent to the oxygen demand generated by the organic wastes of 30 million people. Additional solid wastes arise from both sawmill and papermill operations.

Infectious Agents, Toxins, and Allergens

Infectious agents and toxins are found throughout the total environment. Any animate or inanimate substance on which an infectious agent or the carrier of a toxin depends for survival serves as a reservoir. The conditions under which the various agents may induce disease are not fully understood, but range from direct transmission via contact, air, soil, water, food, and intermediate hosts, to indirect transmission. The total impact of infectious agents and toxins is difficult to estimate. In animals and plants, there are economic losses through deaths, illnesses, retardation of growth, condemnations, failure to conceive or reproduce, and loss of byproducts. In man there are illness, suffering, incapacitation, and death.

By far the most common cause of allergy problems stems from the pollens of weeds, grasses, and trees. It has been estimated that over ten million work days are lost each year as a result of allergic response to pollens. The annual cost of medical treatment for desensitization to ragweed pollen alone is estimated at $100 million.

Plant Residues

All farm and forest operations leave residues at points of production representing a great diversity of materials. While there are some situations under which residues from field crops and orchards can be used advantageously, there are many cases in which accumulated residues lead to troubles if not disposed of in some way.

In forestry operations, tremendous quantities of logging debris are left each year in the woods. This debris constitutes one of the most serious fire hazards in forestry and serves to promote the spread of tree disease and insect damage. Forest debris in stream channels may increase flood damages by temporarily damming and then breaking. Also burning of forest debris may cause air pollution.

Residues from crop and orchard production contribute to pollution. They serve as a source of particulate material and noxious gases when burned. They can be reservoirs for the spread of pests and plant diseases. The presence of phytotoxic substances in plant residues and the production of such substances by micro-organisms may account in part for the adverse effect of a particular crop on a succeeding crop in a cropping sequence.

Sediment

Sediment has a multiple effect. It depletes the land resources from which it is delivered, impairs the quality of the water resources in which it is entrained and degrades the location where it is deposited. Most sediment consists of soil and rock particles eroded from disturbed lands: crop, range, and forest areas; highway rights-of-way; surface-mined areas; stream banks; and construction sites. Sediment becomes a pollutant when it occupies water storage reservoirs, fills in lakes and ponds, clogs stream channels, settles on productive lands and interferes with their use, destroys aquatic habitat, creates turbidity that detracts from recreational use of water, as well as when it degrades water for consumptive or other use, increases water treatment costs, or damages water distribution systems. In addition, sediment is a carrier of other pollutants.

Sediment derived from land erosion constitutes by far the greatest mass of all the waste materials arising from agricultural and forestry operations. Rough estimates of the suspended solids loadings reaching the Nation's streams and lakes from surface runoff show these to be at least 700 times the loadings caused by sewage discharge.

Plant Nutrients

Plant nutrients too frequently move into streams, lakes and reservoirs thereby enabling the growth of unwanted algae and water weeds. Nitrogen and phosphorous are of particular concern. Plant nutrients enter into water from precipitation, municipal sewage, industrial wastes, and runoff from feedlots, barnyards, and agricultural land. Some nutrients, such as boron, can accumulate in the soil to the level of contaminants and adversely affect or kill economic plants.

Mineral and other Inorganic Substances

These contaminants include a wide variety of naturally occurring and manufactured substances such as salts, metals, metal compounds, acids, and alkalis. Sources for these chemicals include acid drainage from mines, degradation of geologic materials and their accumulation in arid and semi-arid soils, accumulation of chemicals dissolved in irrigation water in some irrigated soils, discharge from chemical and metallurgical industries, accumulations from pesticides and impurities in soil amendments.

Pesticides

Considerable concern has been expressed over the ubiquitous occurrence of certain pesticide residues in our environment. Residues of these materials in various stages of degradation have been found at locations far from the original point of application.

During the past five years, the use of pesticides has greatly increased. A wider choice of materials on the one hand and improved application techniques on the other have permitted this increase without a correspondingly dangerous increase in residues, at least in materials consumed directly by man -- as borne out by food analyses, the soil and water monitoring programs, and the monitoring of pesticide concentrations in humans. However, the monitoring programs of the Fish and Wildlife Service and others present clear evidence that certain persistent pesticides are widely distributed in our environment and may be adversely affecting species whose importance to man is indirect. Concentrations of these materials may occur as they move through food chains in natural systems.

Radioactive Substances

Agriculture is primarily a receptor rather than a donor of radioactive pollutants. The major threat to agriculture appears to exist in the form

of nuclear fallout because of war. The most likely threat will be in local situations where accidental release of the byproducts of earthbound use for peaceful purposes brings plant and animal life into contact with radionuclides. Unless wide-scale testing programs are reinstated, the danger of nuclear explosions as a source of radioactive damage in agriculture will likely continue to diminish. The magnitude of this pollution is difficult to estimate. Increased use of nuclear reactors, evidence of radioactive concentration through accumulations such as sediment in salt water estuaries, and irreparable harm that can result from exposure of reproductive and other cells to excessive radioactivity, indicate a need for a continued awareness of the dangers of unpreparedness.

Airborne Chemicals and Particulates

The major airborne chemical contaminants are sulfur dioxide, fluorides, carbon monoxide, ozone, nitrogen oxides, peroxyacetyl nitrate, and various hydrocarbons such as ethylene. One hundred twenty-nine million tons of chemical contaminants are emitted into our atmosphere (annually). Crop plants, ornamentals, and trees are subjected to chronic injury in and near every metropolitan area. Nationwide losses to agriculture and forestry because of noxious chemicals in the atmosphere are estimated to $500 million or more annually. As these chemicals continue to enter the atmosphere, and as capability in diagnosing their damages to plants and animals increase, we can expect estimates of annual damages by air pollutants to crops, ornamentals, forests, and livestock to increase markedly.

Annually, an estimated 30 million tons of natural dusts enter the atmosphere. Most arises from fields under cultivation, deteriorated range lands, and sand dune areas. Other sources are drifting pesticides and such agricultural industries as cotton ginning, alfalfa milling and dehydrating, harvesting operations, feed grinding, and feedlots. Damage from dusts occurs when they fall on vegetation and impair the growth and quality of the product. Dusts also contribute to respiratory ailments of men and animals, affect highway and air vision, damage machinery, and permeate buildings.

Heat

Heat acts as a water pollutant because it upsets the environmental balance in streams. For instance, the amount of oxygen that water can hold in solution diminishes with increasing temperature. The introduction of significant levels of heat into surface water has the same effect as introducing additional oxygen-demanding wastes. Increase in water temperatures can change the environment sufficiently to modify stream suitability for certain fish.

Noise

Noise may be considered as "unwanted sound." Acoustic experts believe that noise levels will grow with the increasing numbers and sizes of machines invading the countryside. Consideration must be given to the welfare of operators of these machines. There are a few documents indicating that many of our domesticated livestock are, in fact, affected by noise. There is evidence of panic and subsequent death of poultry caused by sudden sound.

Socioeconomic Aspects

The concept that most Americans want to live in the city is being challenged. For the many people who really want to live in the country, the dimensions of "environmental quality" extend well beyond those of agricultural and forestry production practices. Overall gains of environmental quality must be paid for. The relevant question is "Who pays how much for what?" Beyond this researchable question lies a series of public policy decisions about who should pay. Adequate and sensitive economic and sociological analyses are required before reasonable decisions can be made.

Systems Analysis

The designers of pollution abatement systems must often choose among a number of abatement procedures, select some point in the continuum of possible pollutant strengths at the discharge point of the system, and identify a particular part of the environment as the sink for the system discharge. Much of the research and analysis applied to these systems has dealt only with bits and pieces of the system. Lack of adequate data and the laboriousness of methods of analysis often severely limit the number of alternatives that could be compared and also prohibits a clear choice among a set of alternatives.

A systems analysis approach is needed. This approach has been successfully developed in recent military-space projects. The systems approach is organized common sense plus modern mathematical tools. It consists of defining, limiting, and analyzing problems; devising mathematical models; obtaining reliable data; investigating the results of alternative actions via the models; scheduling research and development . . . . The systems approach requires a deep understanding of practical aspects of pollution. It requires learning by doing and allows adjustments as the program progresses. It can prevent crises and emotions from influencing decisions of a technical-economic nature.

RESPONSIBILITIES OF AGRICULTURE AND FORESTY RESEARCH AGENCIES

The research agencies of the U.S. Department of Agriculture, State agricultural experiment stations, schools of forestry, and agricultural and forest industries share the responsibility to plan, fund, and conduct research that will clearly disclose (1) the economic and social costs of pollution related to agriculture and forestry, (2) alternative techniques and actions for minimizing or preventing such pollution and its effects, (3) the economic and social costs that would likely be borne by society and specific industries if the alternative techniques and actions were to be chosen, and (4) social and economic benefits resulting from pollution control.

Federal Departments, other than USDA, university research programs in other disciplines, and industries that fabricate products that may contribute to pollution (e.g., motors and chemicals) or reduce pollution (e.g., filters and sewage systems) are also concerned with pollution. It is assumed that research by these agencies will supplement the agricultural and forestry research program described herein. About $250 million of Federal funds are expended annually on pollution research and development by Federal research agencies. Of this amount, the annual USDA-SAES expenditure of funds appropriated to USDA is about $60 million. The SAES also expend about $30 million from State and other non-USDA sources. Large portions of all of these USDA and SAES funds are used for research related to pesticide residue and sediment problems.

The division of responsibilities among agricultural and forestry research agencies depends primarily on (1) the incentives, (2) where competencies and facilities exist or can be provided, and (3) where problems are intense.

To certain industries, continuation in business, at least at the chosen location, may depend on ameliorating the deposit or release of pollutants. In this case, if control technique is not known, incentive for research is high, and it would be expected that a high proportion of research cost would be directly borne by that industry.

If cost of the research is so great, the benefit so unpredictable or the incentive lacking so that private industry will not choose to finance the research, yet research is deemed to be in the public interest, responsibility lies with public research agencies.

In those cases where a major research installation is required and research results generally would be applicable nationwide or in several regions, it seems reasonable that USDA should assume major and primary responsibility

through intramural research agencies or by contracts and grants. In those cases where State needs are unique and demanding, the State agricultural experiment stations and the schools of forestry should assume major and primary authority and responsibility. Where there is clear regional need for research and the application of findings can be regional, the regional associations of experiment stations (the present NC-69 project is an example) and/or regional research organizations or laboratories of USDA should assume the leadership role. Major research installations for regional and national needs should be planned through joint Federal-State effort.

It is assumed that researchers and their administrators will be responsive to and guided by feedback on research needs from private industry, extension workers, and other professional personnel in the broad agricultural industry.

INDIVIDUAL POLLUTANTS AND GENERAL SUBJECT AREAS

Each pollutant and subject area is described under three headings: The Problem, State of the Art for Dealing with the Problem, and Research Needs. Proposed research activities are briefly presented together with projections of levels of scientific effort needed by fiscal year 1977. These levels of effort are summarized in Table 1 in terms of scientist man-years (SMY) 1/. In addition to these data, detailed SMY information is presented in other tables in the Scientific Manpower section at the end of the report.

As a general rule, the total projected SMY's are considered to be allocated between (1) State Agricultural Experiment Stations and Forestry Schools and (2) USDA on a 50-50 basis.

1/ A SMY is defined as the research time of an Assistant Professor or GS-11 or above for one year. When expressed as an average cost per SMY in dollars, it includes his salary plus that of support personnel (such as secretary, technician, animal caretaker, etc.) plus regular operating funds (such as travel, publication costs, instrumentation and expendable items). It does not include the cost of the facility within which he conducts his research. Facility needs are considered in the next to last section of this report.

Table 1. Estimated current USDA, State Agricultural Experiment Station, and Cooperating Forestry School program of pollution research and Task Force projection for FY 1977.

Individual Pollutant or Subject area	SMY's Estimated Current Program	SMY's Projected for FY 1977
Animal and Domestic Wastes	27	140
Processing Wastes	30	133
Animal	(15)	(45)
Crop	(5)	(48)
Forest	(10)	(40)
Infectious Agents, Toxins, and Allergens	197	270
Plant residues	20	50
Sediment	96	254
Plant Nutrients	200	275
Mineral and Other Inorganic Substances	44	95
Pesticides	1743	1753
Radioactive Substances	0	10
Airborne Chemicals and Particulates	41	114
Heat	0	0
Noise	1	7
Socioeconomic Aspects	2	32
Systems Analysis	2	6
TOTAL	2403	3139

ANIMAL AND DOMESTIC WASTES

The Problem

In this report animal wastes is defined as those associated with animal production. Domestic wastes refer to those wastes that originate from farm homes and small rural communities. The problem is that of handling and disposing of these wastes with minimum costs yet remaining within the constraints of water, air, and soil pollution abatement requirements, as well as meeting the requirements for maintaining animal health and product quality.

Current public action programs to abate pollution have placed great urgency on the problem. The major portion of the livestock industry is challenged for continued existence due to the public pressure and lack of knowledge for solutions.

Pollution Associated with Animal Production. Pollution arises from animal excreta and the animal care operations such as feeding, equipment cleaning, pest control (or lack thereof), and animal transport. It may result in air, water and/or soil contamination. The nature of contamination takes many forms such as (1) oxygen depletion and excessive nutrient loads in streams, either of which have reportedly contributed to fish kills; (2) infectious agents that have affected other animals including man; (3) obnoxious odors that cause human discomfort, cause economic losses in the community and may affect animal product quality; (4) toxic gases that may affect farm livestock and man; (5) dusts that cause human discomfort, reduce the efficiency of animal performance, and reduce visibility on neighboring highways; (6) detergents which reduce effectiveness of disposal systems; (7) pesticides which may appear as residues in the product, and (8) unsightly appearance of streams.

The problem has been complicated by changing agricultural situations such as:

- Ready availability of inexpensive commercial fertilizer
- Large concentrated production units
- Reduced availability of labor
- Narrow profit margins
- Land for disposal is less available and is expensive
- Increasing property taxes on structural improvements
- Uncertain markets

It is unrealistic to expect producers to meet the problem without public financial assistance -- particularly in the development of needed technology. The benefits are much greater to the general public than for producers.

Furthermore, the margins of profit are generally too narrow and uncertain to warrant the necessary expense. In many cases the alternate may be ceasing operations at a loss in public food reserves, in producer profits, and income to the community.

Any increase in cost production will, of course, be reflected in an increased cost of product. American livestock production is already having difficulty maintaining its competitive position with other sources of food. Dollar values to the general public are difficult to determine in such areas as protection to public health, animal health, reduced costs of processing drinking water, reduced contamination of acquifers, and improvement of recreational values of water resources. However, in aggregate, they exceed the benefit to the producer.

The magnitude of the problem may be appreciated from the BOD of manure produced from agricultural livestock and poultry in the United States which is estimated as being ten times that of the sewage produced by the human population.

Beef cattle feedlots exemplify the magnitude of the problem. A single 10,000-head feedlot (only about one-eighth the size of the largest) produces about 260 tons of manure a day. With the current trend of increase in feedlot beef production (it doubled from 1957 to 1967), feedlot manure and urine production can be expected to increase from 82 million tons in 1967 to 112 million tons by 1977. Similar examples can be drawn from dairy, poultry, swine, and sheep production units.

Animal Wastes Produced During Transitory Processes. Wastes are deposited at various points in the feeding and marketing system. Initially, the livestock marketing system was rather uncomplicated with most animals moving by rail to large terminal markets and adjacent packing plants. In recent years, the pattern has greatly changed with most animals being moved by truck, and many animals handled through auction markets and packer country buying stations. Considerable amounts of manure and, occasionally, dead animals are deposited at widely scattered points throughout the country. Sanitation of trucks, because of their uncontrolled movement, has become very important and results in liquid runoff at wash points near these small terminals.

Presence of pathogens in such manures is well known and problems of cross infection have resulted as livestock moves to and from farms and feedlots and on to slaughtering plants. Subclinical diseases may cause small losses to producers while occasionally serious disease outbreaks occur such as the vesicular exanthema epidemic some years ago. It is known that stags, boars, and sows, which tend to remain longer in such facilities than more desirable hogs, are more likely to have salmonella contaminated feces when slaughtered.

Rural Domestic Waste Disposal and Water Supply Systems. Rural domestic wastes refer to both human excreta and to the wastes arising from food preparation and other byproducts of living. They may be associated with single family (owner or tenant occupied) homes; on farms or other rural areas including communities of near 5,500 people (the general upper limit guide for the Farmers Home Administration's action programs). There may also be housing for the elderly or migratory workers. Recreational area needs attention, too. It is estimated that there are 17 million homes in the rural areas. Less than one out of four have water piped into their houses

Pollution control in rural water systems is closely related to the disposal of domestic wastes. Potable water is essential for the human health and maintenance of the quality of products as related to either the animal's drinking water or to the cleansing of product handling equipment.

State of the Art for Dealing with Animal and Domestic Wastes

Animal Production, Transit, and Marketing. The problem is not easily solved. Not only are there serious limitations in the knowledge and equipment available to solve the problem but any solution will be costly. Proposals for utilization of wastes have been made and instituted for some animal wastes. Fertilization of crop and forest land continues as a method of utilization in some cases, but new knowledge is needed on both the technology to reduce costs of handling and on the constraints of technology such as the ability of vegetation and soils to accept wastes. Home and garden fertilization and animal feeds are other potential uses. For the present, these are generally considered as cost "off-setting" proposals. Marketing of animal waste byproducts from diverse type and sizes of production units widely scattered about the country also presents a major bar to making a waste utilization process self-supporting. Animal wastes must, at least for the present, be considered as a burden.

Existing practices and technology in destructive disposal are centered about urban waste handling techniques. City sewage disposal plants are too expensive and frequently would not do the job even if livestock producers could afford them. Animal wastes disposal presents quite a different problem from that of city sewage. Cost estimates of one municipal type system that is considered a likely prospect for hog wastes is about $25 per pig marketed (lot capacity), and in limited field tests to date, the results are too erratic to rate the system a successful solution. It should be noted that operating costs of such a system would be $2.50 per pig (reared). Aerobic lagoons have proven successful for disposal of animal wastes when properly designed. Their utility is limited to relatively small operations and even then technology is lacking for practical effluent treatment to meet quality standards of many rural streams.

Technology in controlling air pollution from animal production activities is in its infancy. Sprinkling of feedlots has proven a successful means of alleviating dusts. However, odors are a persistent problem. To date, masking agents or other chemical deodorants are the principal corrective measures. High costs, the substitution of one air pollutant for another, and limited effectiveness are the limitations of this control measure.

Domestic Waste Disposal and Water Systems. The outdoor privy is a solution that is satisfactory for some of these applications when properly managed. Septic disposal systems are useful for other applications. Current knowledge on septic disposal systems is generally adequate. However, there are some circumstances where septic systems do not operate properly and the cost of other standard waste treatment facilities is beyond the user's ability to pay for them. Modifications or alternate systems are needed--particularly for low income families.

Technology is adequate for pathogenic decontamination in farmstead water supplies but much is to be learned of the contamination of water supplies by nitrates and needed corrective measures. Little is also known of the various mineral and organic impurities in water as they may affect animal production.

Research Needs

** Level of Effort **

Estimated Current - 27 SMY

Recommended FY 1977 - 140 SMY

The urgency of this program requires the immediate attention of a large multidiscipline research force to be assembled as quickly as possible and working on several concurrent alternatives no one of which is expected to be a panacea for all problems even within one geographic area or for any one class of livestock.

Pollution Associated with Animal Production

1. Develop basic criteria for use in planning and programing various research approaches. This would include production rates, physical properties, bacteriological and other characteristics of wastes produced under various handling and housing systems for each class of livestock. Climatic and nutritional variables will require this work to be done at several diverse locations within the United States 1977 SMY 20

2. Improve current systems of animal waste management so that pollution control may be achieved at a lower cost and in a manner compatible with modern agricultural practices. Attention will need to be given to labor saving and convenience features to make them more acceptable. Lagoons and aeration ponds have been successful in some places but not in others. Why? Incinerators may be useful for some applications. Detention ponds and land application present hazards to acquifers. Methods and maximum application rates to avoid toxicity to plants, etc., as well as the true economic benefits need to be known for the variety of conditions that exist in the United States. Research of this type will need to be carried on at several locations to account for climatic, geographic and management system variables. <u>1977 SMY 15</u>

3. Develop new concepts for the collection, handling, treatment, and disposal of animal wastes. Scientific achievements in related areas, fluidized combustion chambers, wet oxidation, electro-osmosis and others should be explored as possible methods for converting animal wastes to valuable resources or to less objectionable excesses. Profitable, or at least, cost-offsetting uses of animal wastes should be considered. Heat treating and drying for feed and ensiling are examples that are now beginning to receive attention. This area is sufficiently broad that it will require large resources of men and dollars. It lends itself to being programed into many subjects. <u>1977 SMY 20</u>

4. Development of means to remove or ameliorate pollutants, once they are released. Odor masking, chlorination, radioactive treatment and hydroponics are examples of procedures that will bear further investigation. <u>1977 SMY 7</u>

5. Improve the production practices and facility designs in livestock and crops so as to minimize the production of waste material, to maintain the wastes in a form most suitable for treatment, and to reduce waste release into the environment prior to treatment thus making waste management more meaningful to the overall animal production or crop production scheme. Waste removal, cleaning and sanitation systems to reduce labor and increase efficiency of production would be inherent in this effort. <u>1977 SMY 13</u>

6. Evaluation of hazards -- primarily disease and other hazards to the farm itself. For example, toxic gases are emitted by manure pits below slatted floors. Other agencies are expected to evaluate hazards to those outside of agriculture. 1977 SMY 12

7. Develop a least cost method for sterilizing liquid and solid animal and domestic wastes. Use of wastes for animal feeding, use of diluent for potable water or using liquid, solid, diluted or reduced wastes for soil amendments all should require that such wastes are free of viable animal and human pathogens. We presently lack economical, feasible technology adequate for this purpose. Two hypotheses are proposed: (1) improved and controlled processing, including time and temperature sufficient to destroy all complete viruses and thermophilic bacteria including their spores. Such a method must be accompanied by adequate sampling and testing methods to demonstrate that each batch or final product is indeed sterile. (2) Sterilizing might be achieved by incineration, fermentation, steam treatment or enzymatic action. Obviously, preliminary concentration or reduction must be compared costwise to processes involving dilution. 1977 SMY 7

8. Evaluation of various animal production facilities as a system both for productive efficiency and its role in the community. This is a broadly based activity encompassing labor efficiency, feed efficiency, socioeconomic relationships and pollution. 1977 SMY 10

9. Exploration of usages in combination with agricultural, municipal, and industrial wastes. Composting and soil building are examples that have already met with some success. Included in this research would be studies of the capability of soils and crops to handle these wastes as well as methods and equipment for increasing the effectiveness of using soils and crops in the disposal system. 1977 SMY 16

Animal Wastes Produced During Transitory Processes

1. Research to find solutions for more economical handling and disposal of such wastes are needed. At the present time, this research might better be carried on at farm and terminal market level where problems are more urgent. Such solutions as may be found can then be adapted to solve problems existing at these isolated country points.

1. (Cont'd)

It is anticipated that, as some of the answers are found in the production and processing systems, some research effort will be shifted to problems that are peculiar to the transitory systems. 1977 SMY 4

Rural Domestic Waste Disposal and Water Supply Systems

1. A research program is recommended that will evaluate alternate methods of rural domestic wastes disposal and develop waste disposal standards for migratory labor and will involve modification of development of improved techniques (including improvement of percolation rate) and exploration of alternate methods of disposal of human excreta (e.g., electric toilets). Emphasis would be placed on needs of low income families. 1977 SMY 4

2. A continuing research program is needed to evaluate the role of various impurities in water in relation to their deleterious effects on health, product quality, and plumbing systems themselves. As needed, economical and effective corrective measures will need to be developed such as methods of preventing contamination or equipment to remove the contaminants--particularly chemical contaminants. 1977 SMY 4

3. Evaluation of the affect of various mineral and organic impurities of water as they may affect animal production. 1977 SMY 4

Economic Aspects of Animal and Domestic Wastes

1. Evaluate costs and benefits to determine economic merits of alternate ways for dealing with animal wastes and the extent to which control measures should be applied. Some questions requiring additional research are: (1) What are the economic efficiencies of different systems of production under present constraints? (2) How will new constraints created by new regulations controlling stream pollution affect the economic efficiency of these systems? (3) What are the possible new markets for animal wastes? (4) Are there back haul situations which can help overcome the problems of transporting these bulky wastes long distances? (5) What are the opportunities for cooperating with lawyers and political scientists in initiating institutional changes needed to set aside areas for the production of livestock, even though this

1. (Cont'd)

production creates odors that are offensive to the senses? (It may be necessary to set aside certain areas as public-private livestock producing authorities. Such authorities which would exemplify a zoning rather than a multiple-use policy, would protect livestock producers from the hazard of abatement action on the part of the public) and (6) What are the most acceptable ways for the public to pay for protection from this kind of pollution; i.e., increased costs of consumer goods, higher taxes, etc? 1977 SMY 5

Research in the entire area of animal and domestic wastes will be expensive. Under the first three subsections above SMY's should be financed by at least $60,000 at the working level. The facility needs for this work are partly in existence at State experiment stations and Federal installations. However, in most projects, additional facilities and equipment will be needed. A National Research Laboratory to serve as a center for Animal Waste studies has also been proposed. Endorsement is given to the development of this facility.

The following are examples of the nature of some of the benefits that may be derived from this research:

a. In terms of pollution abatement, approximately three-fourths of the population of the United States would benefit.

b. When considering the prospects of cost-offsetting solution, the land fertilization values should not be overlooked. American farmers spent 1,500 million dollars in 1966 to purchase six million tons of N, 4.3 million tons of P_2O_5, and 3.5 million tons of K_2O. Human sewage could provide 300,000 tons of N and 200,000 tons of P. With the N and P available from animal wastes, near ten times that of the human population and an additive factor of treatment costs, a closer look at land application is warranted.

c. The survival of the major part of the livestock industry in the United States is challenged. This research is necessary to assure its continuation.

    (1) If a municipal type sewage system were developed that would be adequate for animal wastes of each major producer, the total cost of conversion for all producers would be about 90 billion dollars.

(2) Current practice (assuming land disposal) places manure handling costs at 290 million dollars annually. Even before pressures of pollution abatement, this cost was considered sufficiently great to justify research toward reducing it.

(3) Relocation has been suggested. This presupposes that the loss of the livestock industry would not impair a community's economic prosperity. In addition, the cost to the industry may be prohibitive. Within the last six years, 43 California dairy farms having a total of about 12,000 cows have had to move from the Los Angeles area to the Bakersfield area, in Kern County, a distance of about 80-100 miles, because of their "noncapatability" with activities of the expanding Los Angeles Metropolitan area. Costs for new facilities for these dairies averaged about $112,000 each, of which $35,000 to $42,000 was for constructing milking facilities. The total relocation cost within this one county for the milking facility portion of these enterprises alone is over $1.6 million.

Relocations have also been made to the Chino and Corona areas of San Bernadino and Riverside Counties, respectively. Such relocations have occurred in several other areas and States with the probability of the problem increasing. These relocations apply to all classes of livestock. The costs to agriculture are high. Even in relocated facilities, waste disposal remains a problem.

PROCESSING WASTES

The Problem

Sources and Effects. Processing of agricultural commodities into food products, textiles, leather, feeds, and industrial products and of wood into pulp and paper products inevitably results in loss of organic matter. This loss may range from a small amount up to 25 percent or more of the raw material undergoing processing. A common feature of such processing wastes is their consumption of oxygen from the water of streams and lakes into which the effluents are discharged. In general the adverse effects are proportional to the organic load, measured in terms of biochemical oxygen demand (BOD) imposed on such receiving waters. Preservation of aquatic life and of the desired ecologic balance require no less than a certain minimum concentration of dissolved oxygen and that BOD be held within limits. In addition to the detrimental effect of soluble organic materials, water uses can be impaired by excessive discharge of hot effluents, settleable solids, and colored matter.

The degree of pollution depends on an interplay of the strength of the waste, the extent of dilution after introduction into the body of water, and the socially desirable or legally protected uses to which the receiving water may be put. Resulting problems may be seasonal, depending on production schedules and stream hydrology, or may extend throughout the year and therefore require different technological solutions.

Dumping of waste solids from agricultural processing onto the land often leads to emission of foul-smelling gases and to other problems. Incineration of the waste solids is not always a solution since it is likely to cause air pollution.

Losses of organic material in peeling, trimming and slicing of fruits and vegetables, in cleaning dairy plant equipment, in slaughtering and processing meat animals and poultry, in the wet milling of grains and soybeans, in sugar refining, in wool scouring, in wet processing of textiles, in treatment and tannage of hides, in processing of fats and oils, and in production of pulp from wood, all contribute to the problem of pollution attributable to agricultural processing.

Liquid, solid and gaseous wastes arise from the manufacture of pulp, paper and cellulosic products. Large quantities of water, averaging a total of 40,000 gallons per ton of paper produced, are used in the successive steps of debarking, pulp wood grinding, chip refining, chemical pulping, washing, bleaching, screening, paper sheet formation, and chemical recovery operations.

Solid wastes arise both from sawmill and papermill operations. Processing of logs into lumber gives rise to coarse residues as well as sawdust. While sawmill residues find increased use in wood pulp production, large quantities still remain for disposal. Pulp and paper effluent treatment yields hydrous organic sludges. These sludges are now, to an increasing extent, being mechanically dewatered to a semi-solid state and must be treated or disposed of as solid wastes.

Atmospheric emissions arise from the disposal by burning of sawmill wastes. Burning of papermill sludges is still in its infancy but is expected to become more significant as restrictions on, and costs of, land disposal increase. Gases with undesirable odors, originating from reduced sulfur compounds, and finely divided alkaline particulate matter are given off in operations of the kraft pulping process.

Effluents from pulp and paper manufacture, in common with those from other types of agricultural processing, can deoxygenate receiving waters, produce sludge deposits and encourage abnormal aquatic slime growths. Brownish water, resulting from wood pulping and bleaching operations, constitutes a unique problem. This discoloration resists known methods of chemical treatment, proven in practice, and persists after high efficiency biological treatment. To a lesser extent but still a problem, some papermaking effluents impart a whitish turbidity to receiving waters.

Magnitude. The estimated total pollutional loads of processing wastes from selected industries are presented in Table 1. Data for this table were taken from "Agricultural Processing Wastes: Magnitude of the Problem," S. R. Hoover and L. B. Jasewicz, Amer. Asso. for Advancement of Science, Publication 85, pp. 187-203 (1967).

The figures in the table are based on information obtained from articles in sanitary engineering journals, U.S. Public Health Service Industrial Waste Guides, and from textbooks. Accurate current estimates are unavailable from the fermentation industry, soap industry, frozen fruits and vegetables processing, and from certain other industries. Wastes from these processing industries, however, carry high pollutional loads. Most of the estimates given in the table were made a number of years ago and do not reflect recent expansions in many industries, notably potato processing. The extent to which processing wastes reach streams without treatment and the decrease in pollutional load achieved in the instances of treatment are major unknowns. The estimates, although incomplete and known to be low in certain cases, serve to establish the fact that a huge total pollutional load is involved in agricultural processing.

The data in the table are given in millions of pounds of BOD and as the equivalent in population (PE) required each day to contribute sewage equal to this biological oxygen demand.

Table 1.

Estimated Pollution Loadings of Selected Agricultural Processing Industries

(From Hoover and Jasewicz -- See reference in previous page)

Processing Industry	Potential Daily BOD Million lbs.	Potential Daily Population Equivalent, PE (Millions)
Canning	1.3	8.0
Corn wet milling	0.13	0.8
Cotton processing through basic dyeing step	0.86	5.14
Dairy products	1.99	11.93
Hides and leather	0.03	0.18
Meat slaughtering and packing	2.17	13.0
Paper and pulp	36.0 *	216.0 *
Potato products	0.35	2.11
Poultry	0.22	1.3
Soybean	0.014	0.085
Sugar refining	0.8	4.8
Wool scouring	0.1	0.6

* The National Council of the Paper Industry for Air and Stream Improvement estimates that the daily organic loads from the wood pulp industry plus the paper products industry, after treatment, now total 5 million lbs. BOD and 30 million PE. Figures in table are before treatment

According to the National Canners Association, most of the canning waste receives treatment before reaching waterways. The corn wet milling industry has a relatively low waste in consideration of its size. The very appreciable soluble organic wastes from cotton textile mills are primarily carbohydrates. The dairy products industry is one of the largest from standpoint of potential organic load through its operations in fluid milk, evaporated milk, dry milk, Cheddar and cottage cheese processing. Whey from cheese manufacture is by far the principal waste stream in dairy processing.

Wastes from manufacture of animal skins into leather, while not outstanding in total effect, present serious individual problems. Slaughtering and meat packing together constitute one of the very largest sources of potential BOD load among the food processing industries.

The processing of wood into pulp and paper gives rise to the greatest organic load of any industry related to agriculture. Conversion of wood into pulp produces from 500 to 2,000 pounds of dissolved organic matter per ton of pulp. This noncellulosic material contains large amounts of lignin and about 20 percent fermentable sugars.

Total paper production is nearing 50 million tons annually. The liquid effluent generated totals two trillion gallons per year, or six billion gallons daily. Forty thousand gallons of water are used per ton of paper produced. In the past, a large portion of the pulp industry's effluent organic load was accounted for by the older sulfite pulping process; these mills were operated without benefit of chemical and organic recovery processes and gave rise to unusually strong effluents. This process, however, has diminished in importance. Furthermore, a growing number of the remaining sulfite mills are now equipped with spent liquor recovery systems. The pulp and paper industry today contributes five million pounds BOD (30 million PE) daily to the nation's receiving waters. This is considerably lower than the potential daily load estimated in the literature in 1964 and given in Table 1.

Solid wastes production from pulp and paper manufacture now total approximately 1 to 1.5 million tons annually. Volume of sawmill residues is estimated at 1.3 billion cubic feet, or approximately 15 percent of total lumber cut.

A substantial segment of the pulp industry, that is responsible for production of nearly 25 million tons of kraft pulp annually, produces malodorous gases to the extent of 2.5 to 25 pounds organic sulfur and 3 to 15 pounds particulate matter per ton of kraft produced.

Distribution, Biological and Sociological Implications. Virtually every State is faced with the problems of wastes arising from the processing of agricultural crops and/or forest products. We process an ever-increasing proportion of our farm crops. Our expanding population requires increasingly larger amounts of food, fiber, and forest products. Our increasing

urbanization multiplies and concentrates the wastes due to man. It is indicated that at the present level of waste treatment, organic industrial wastes will become a greater source of river pollution than municipal sewage.

The processing of farm products into foods is the main agricultural processing industry. The nearly 18,000 industrial establishments presently engaged in food processing are well scattered, with the present tendency for management to locate the larger ones in small towns, suburbs, or in rural areas. Dairy processing is concentrated in States such as Wisconsin, New York, and Missouri particularly with respect to cheesemaking, but is rather distributed along with population so far as fluid milk production is concerned. The meat industry is no longer concentrated in Chicago and a few other Midwestern cities but is more decentralized with large new plants in the West. While the processing of a specific crop is often concentrated in areas where that commodity is a high production item, the overall effect is that most States possess one or more sizable agricultural processing industries. The wood pulp mills are distributed through the important timber-producing areas of the nation, concentrating in the Pacific Northwest, the Gulf Coast and South Atlantic States, New England, and the upper Midwest. Paper mills are more widely distributed, with proximity to market outlets and to secondary fiber sources serving as additional plant-location factors. With approximately 1,000 pulp and paper mills in the United States, there is hardly a major watershed that is not the site of one or more mills.

Trends. The quantity of wastes arising from processing of agricultural commodities is continuously on the increase. As problems became more serious, regulatory agencies have called on industry to provide more extensive treatment of wastes and sharply reduce the pollutional effect of effluents discharged to streams. National legislation now makes it imperative that States develop satisfactory water standards or accept Federal regulation instead. Industry is meeting the problem by installing waste control and treatment systems. Cost of treating processing wastes must ultimately be borne by the public either by paying increased costs for the finished products, or by taxation. While much has been done and considerable information developed concerning pollution abatement, there is urgent need for further investigations on waste problems to yield more effective treatment measures with minimal costs.

The general pattern in the industries using agricultural products as raw materials is that of steady growth -- of improved efficiency and productive capacity in existing plants and construction of new plants. For example, the rate of growth of the pulp and paper industry is 5 percent annually, while the increase in number of new mills is perhaps 1 to 2 percent annually. As in other American industries, the trend continues toward mergers and acquisition of companies by larger firms in the same field or by "conglomerate" corporations involved in a number of industries.

State of the Art for Dealing with Processing Wastes

Present Effort. Research and development work on treatment of industrial wastes is carried on by the Federal, State, and municipal governments and by private industry. An extensive research program on waterborne wastes is carried out by the Federal Water Pollution Control Administration (FWPCA) of the Department of the Interior, and research on radioactive substances, air pollution, and solid wastes is conducted by the Public Health Service, Department of Health, Education, and Welfare. The Federal Water Pollution Control Act, P.L. 660 of the 84th Congress, directed the establishment of cooperative programs for research, training, and dissemination of information.

Utilization research organizations in USDA and the State Agricultural Experiment Stations have given much attention in the past to conversion of troublesome processing wastes to useful byproducts. Examples of such research include contributions toward the development of: sugar beet, citrus, pear, tomato, and potato pulp and trimmings for feed components; feed molasses produced by concentrating citrus and pear juices derived from partially extracted or from unsound fruit, propagation of yeast on press liquors from citrus fruit and pears, and on cheese whey. Current research effort on a modest scale seeks to alleviate pollution connected with olive pickling brines, lye peeling of potatoes, recovery of nitrogenous constituents from potato processing waters, and on the development of new products from cheese whey. The current research effort has been made possible by redirection of funds.

Present contract research supported by FWPCA grants is investigating pollution in the leather, canning, sugar beet, potato, meat packing, and fruit processing industries.

A continuing and growing effort is underway on the part of individual companies and organized industrial groups to solve waste treatment problems peculiar to their operations. The industrial effort involves all categories in the processing of agricultural commodities and forest products. The National Canners Association and the National Council for Stream Improvement (of the Pulp, Paper and Paperboard Industries) are good examples of industrial organizations that have attacked and continue to attack pollution problems, often in cooperation with State and Federal government institutions and with equipment suppliers. Spent liquors and liquid effluents from pulping and papermaking continue to receive much attention by industry. Efforts to reduce the BOD of these forest products wastes have already resulted in capital expenditures exceeding $300 million for treatment facilities, with the annual rate of increase now exceeding $50 million. The rapid growth of such facilities has itself created a need for research designed to optimize selection and application of suitable effluent treatment and control processes.

While the resources now available for pollution research may seem substantial to some persons, the problems are manifold, difficult, and demand solutions. The existing staffs and facilities fall far short of what will be required for concentrated attack on agricultural processing wastes.

Current Technological Know-How. Studies have defined and measured the dimensions of some of the problems in liquid wastes, solid wastes, and atmospheric pollution. Measurements have been made on the extent to which liquid wastes containing organic substances deoxygenate the stream waters into which they flow; observations have been made of deposition of sludge and slime growth along stream bottoms.

In treatment of wastes there have been considerable advancements in the state of knowledge. The readily-oxidizable organic matter in such wastes is being treated successfully by aerobic processes in trickling filter and activated sludge systems. Disposal by spraying or ditch irrigation on fields and woodland is effective for certain wastes such as those from dairy and fruit and vegetable processing, given proper soil conditions. Lagoons are considered successful in some instances and far from successful in others. Where lagoons are unsuccessful, failure can often be attributed to lack of sufficient aeration.

Past research has provided a basis for a certain amount of byproduct recovery, reduction of the volume of wastes, and for improved treatment of wastes. The FWPCA and its predecessor agency provides valuable background information in its Industrial Waste Guide series and related publications, at least eight of which deal with agricultural processing: Cotton Textile Industry; Milk Processing Industry; Fruit Processing Industry; Meat Industry; Cane Sugar Industry; Wool Processing Industry; Potato Chip Industry; Wastes from the Poultry Processing Industry. In a current FWPCA series, now in process of writing and publication, called Industrial Waste Profiles, six of the completed bulletins are addressed to agricultural products: # 3 Paper Mills; #4 Textile Mill Products; #6 Fruit and Vegetables; #7 Leather Tanning and Finishing; #8 Meat Products; and #9 Dairies.

In byproduct recovery, a number of established successes have stemmed from research developments. A portion of the sugarcane bagasse supply is used for making insulating board. Dried sugar beet and citrus pulps are large-volume commercial feed components, as is also citrus molasses. Yeast propagated on spent sulfite liquor comprises a moderate-size commercial development, and yeast is being propagated on a small scale from cheese whey.

Past research has developed commercial products from the solids of spent sulfite liquor including surface-active agents, binding agents, and vanillin. In the category of surface-active agents, lignin sulfonates were produced in a volume exceeding 440 million pounds in 1966.

A strong effort is underway to reduce the volume of waste waters from all types of processing through segregation of strong from weak wastes and inplant recirculation of waters carrying low pollutional load; this can simplify recovery of dissolved wastes.

In many instances it is difficult or impossible to convert a waste into a byproduct that will sell for its cost of recovery. Sale of a byproduct at a loss may in the end be justified, however, in that it reduces the cost of full disposal-treatment. In many cases, the obvious course is to treat the waste so as to reduce the BOD to a minimum and then discard the residue. A good example is the Department's contribution in development of the extended aeration modification of the activated sludge treatment of milk waste. In this, the nutrients are used in propagating micro-organisms, with accompanying lowering of BOD. The micro-organisms can then be digested or biologically oxidized to give an effluent much lower than the original BOD of the influent. This system is in wide usage in dairy plants, other food processing plants, and in some sewage plants.

Effluents from agricultural processing are being treated through a variety of other biological processes including lagooning, aerated stabilization basins, and irrigation disposal. Controlled discharge on the land should be employed to utilize available assimilative and oxidative capacity most effectively.

Development of methods to permit use of waste wood as pulp mill raw material input has made it possible to dispense with incineration in the old wigwam-type burner and the accompanying atmospheric emissions. Particulate atmospheric emissions from kraft mills continue to be controlled by use of high efficiency electrostatic precipitators and wet scrubbers. Odor emissions have responded to combustion of low-volume noncondensible gas streams and oxidative fixation of sulfides by aeration of kraft black liquor. Expenditures in the forest products industry for control of atmospheric emissions now total nearly $100 million.

Research Needs

(All Processing Wastes)

** Level of Effort **

Estimated Current - 30 SMY

Recommended FY 1977 - 133 SMY

Comparison of the present reservoir of data and knowledge of processing waste problems with what should be known shows that while substantial progress has been made, there is a long way yet to go. We need to know more

about the strengths of liquid wastes, how to remove or reduce the concentration of pollutional components in a more economical fashion, and how to reduce the amounts of nutrients finding their way into streams. We likewise require more information on utilization and disposal of waste solids left from agricultural processing. Control of atmospheric emissions arising from raw wastes and from incineration of solids comprises another general category of research needs. Meeting the challenge of these problems will require expanded programs by both government and industry. Many lines of study now being neglected should be investigated.

In considering waste research needs of agricultural processing, we are dealing with a composite of multibillion dollar industries very important to our well-being, our personal requirements, and to our Nation's economy. For example, pulp and paper products alone have an annual wholesale value exceeding $15 billion and provide us with manifold necessities.

In the processing of agricultural commodities there is good potential for improving methods so that less waste results, in reduction of inplant water use, in development of new methods for treating wastes, and in by-product recovery. Increasing needs for protein in the future point to the advisability of giving additional attention to propagating cellular protein by fermentation of carbohydrates occurring in wastes.

(Animal Processing Wastes)

** Level of Effort **

Estimated Current - 15 SMY

Recommended FY 1977 - 45 SMY

<u>Collection and Disposal of Wastes which Cannot Be Handled in Usual Biological Treatment Systems</u>.

Such wastes consist of pen manure, paunch contents, fats, blood, toxic liquids, animal hair, hide trimmings, and hooves. Excepting toxic liquids, each of these materials in the past had a value as useful raw material in agriculture or in industry considerably in excess of collection and processing costs and was regarded as a profitable byproduct. Competing products and changes in agriculture production practices have eroded product values to such an extent that most of these animal byproducts are now either in the waste category or may be regarded as wastes in a few years. Research is needed to improve collection practices to find new uses, if possible, and to develop less expensive, appropriate disposal means. The fact that these materials (manures in particular) in the raw state may harbor pathogens such as salmonella must be recognized in the search for new uses and means of disposal. In the case of pen and paunch manures, composting

has been used as a means of reducing waste volumes and also of providing fertilizers for truck farm crops, lawns, and gardens. Investigations are needed to determine least-cost methods of marketing and/or distributing such materials to users.

1. Develop more economical blood drying methods for abattoirs killing less than 1,000 head of cattle (or equivalent) per week. <u>1977 SMY 3</u>

2. Develop new uses and low cost means for disposing of keratin protein material (animal hair, hooves, and hide trimmings). <u>1977 SMY 5</u>

3. Investigate possibilities for improving the utilization of various animal wastes (processing plant) by conversion into FDA-approved animal feed products. Include study of combination with dairy wastes. <u>1977 SMY 7</u>

4. Investigate and develop new low-cost transport systems for solids and liquid slaughter-plant wastes. <u>1977 SMY 3</u>

5. Investigate means for sterilizing manures economically by various heat sources and by irradiation. <u>1977 SMY 2</u>

<u>Improvement of Existing Waste Treatment Processes and Development of New Waste Treatment Processes and Useful Products</u>.

Research is needed to find ways to improve existing primary treatment processes so that more commercially-valuable fat can be salvaged and other solids removal increased. Facilities for anaerobic-aerobic lagooning treatment systems need to be designed so that they can be built on smaller plots. Because not enough is known about the effects of recirculation on process efficiency and the conditions actually prevailing in anaerobic lagoons, design and operating practices tend to be based on intuition and opinion rather than on fact. Odors and erratic results can probably be reduced or eliminated. New treatment processes including those involving the production of useful protein products are under study now. The efforts should be expanded.

1. Investigate possibilities for increased fat removal from raw plant effluent so as to permit raw waste to be used for irrigation. <u>1977 SMY 3</u>

2. Study the anaerobic-aerobic lagoon system to define design parameters and determine proper management and maintenance procedures. <u>1977 SMY 4</u>

3. Investigate the possibilities for using meat and dairy plant wastes to grow vegetable or fungal proteins to be used for animal feed purposes. 1977 SMY 2

4. Investigate new means of handling whey. How can foam-spray drying be developed so as to be successfully carried out in a number of commercial spray driers, modified for injecting gas into the concentrated whey input? To what uses can acid cottage cheese whey be applied, once the enormous quantities now wasted are concentrated and dried? Can whey be successfully employed as a carbohydrate-protein-minerals component for food concentrates acceptable to hungry people in the developing countries? As a question of economics, how far is it feasible to truck whey to a central evaporation plant? 1977 SMY 6

Demonstrations and on-the-spot technical service should be furnished to dairies that are trying extended aeration, spray irrigation, and field percolation in instances where recovery of the whey is not practical. Can liquid whey be successfully worked into silage?

Inplant Process Changes as Solutions for Reducing or Eliminating Processing Wastes.

In food processing, the greatest part of the waste volume results from the sanitizing operations. Research is needed to develop means of achieving high levels of process sanitation at substantially reduced water-use levels.

1. Investigate means of dehairing hogs that will reduce water-use requirements. 1977 SMY 3

2. Investigate possibilities for achieving increased carcass sanitation while taking suitable means to reduce wash water use in slaughtering. 1977 SMY 4

3. Study sanitizing procedures used in meat, poultry and dairy plants with objective to develop new means of "dry cleaning" the premises and equipment while maintaining sanitation along with reduced volume of waste effluent. 1977 SMY 3

The processing of dairy products probably produces the greatest amount of liquid wastes in the food industry. New handling methods should be devised that will lessen the large amount of fluid milk spilled on the dairy floor and lost in cleanup of equipment and lines. Aside from contributing to pollution, the enormous amounts of lactose, protein, and mineral substances wasted from Cheddar cheese and cottage cheese manufacture constitute a nutrient loss the Nation cannot afford.

(Crop Processing Wastes)

** Level of Effort **

Estimated Current - 5 SMY

Recommended FY 1977 - 48 SMY

Wastes from the canning, freezing, and dehydration of fruits and vegetables comprise one of the most troublesome problems of the processing industry. High percentages of the deciduous fruit, citrus fruit, berry, vegetable, and potato crops are now processed. Pulp and peelings, trimmings, seeds and pits, wash water, and blanch water accumulating at the processing sites must be carefully studied to see where waste reduction can be effected. Feed outlets for dried pulp should be advanced wherever possible.

In sugar manufacture, the quantities of cane bagasse are much too large to fill the needs of wallboard production, and the major portion still has to be incinerated. Liquors and sludges of high BOD are troublesome at sugar refineries, particularly at sugarbeet plants.

Cotton and wool processing are the sources of considerable wastes at various stages of separation of the fiber and conversion to cloth. A major part of the organic material present in cotton processing effluent comes from the carbohydrates in sizing. For several years it was thought that the newer type of synthetic sizes would greatly lower the BOD of the effluent from the desizing step; however, it appears that the ecological situation has been adjusted so that the newer sizes lead to about the same pollutional load as their carbon-equivalent in starch sizes.

While industry has accomplished a great deal in reducing wastes arising from grain milling, definite needs call for further developments. In processing oilseeds; e.g., in the recovery of protein from soybean meal, protein loss in the extracting solution should be reduced.

1. <u>Potatoes, fruits, and vegetables</u>. Pilot plant methods should be developed, followed by demonstrations in commercial plants for removal from processing waters of amino compounds by ion-exchange procedures and proteins by coagulation. Are flocculating agents effective in removing solubles from processing waters? Can reverse osmosis be successfully employed in concentrating processing effluents? What uses can be developed for nitrogenous constituents separated from processing waters? What are the comparative costs of dewatering and drying pulp and peelings by different methods? Are new methods of peeling; e.g., flame peeling or combination of alkali and radiant heat, practical as a way to reduce volume of processing water with its high BOD?

1. (Cont'd)

   Can hot water or steam blanching with their accompanying undesirable leaching of organic substances be replaced by other methods of blanching; e.g., by microwaves? Can processing waters containing nutrients be used as a substrate for industrial fermentations? 1977 SMY 15

2. Pickling brines. How can brines be used more efficiently in olive pickling to minimize organic pollution? What can be done to reduce the volume of spent brines, following the processing of cucumber pickles, and keep the high salt content from entering streams? 1977 SMY 3

3. Citrus pulp drying. How can air pollution arising from the drying of citrus pulp be minimized? 1977 SMY 2

4. Soybean processing. Can an economical process be developed for dry milling of defatted soybean meal to recover protein concentrate? In the absence of such a process, a method should be developed for recovery of the protein from liquid soybean whey that is now wasted. 1977 SMY 5

5. Tomatoes. Development of tomato processing operations to permit maximum amount of in-field processing. 1977 SMY 2

6. Rice. Rice hulls accumulate each year to an enormous tonnage. They are unsuitable for feed. Is it feasible to recover silica from the ash after burning the hulls? Can charcoal briquettes and compressed simulated logs be successfully made from rice hulls? 1977 SMY 2

7. Cotton. Develop methods for decreasing pollution in textile milling, with emphasis on solvent dyeing and finishing processes. To what extent does SO_2 in the atmosphere contribute to degradation of cotton cloth and how may it be prevented? How can dye fading by oxides of nitrogen in the atmosphere be prevented?

   Cotton linters are too short to be woven into anything but very coarse cloth. Part of the linters supply is used as raw material for cellulose derivatives. What can be done with the remainder of the large quantity of linters made available continuously? 1977 SMY 7

8. Grain processing. Develop a method for producing single cell protein by fermentation of grain wastes. Can microorganisms be propagated on the carbohydrates of the waste to produce gums and other useful fermentation products? 1977 SMY 3

9. Damaged oilseed supplies. What can be done with the occasional lot of peanuts and cottonseed that is infected with aflatoxin or contaminated with pesticide residue? 1977 SMY 1

10. General. Cannot ways be found to treat processing water so that it is suitable for irrigation purposes in arid areas such as Idaho, Oregon, Washington, and California deserts?

    Research is needed on disposal of processing waste water by diffusion into the soil. Percolation is an excellent method of reducing pollutional load before the effluent joins the underground water supply.

    The water usage and movement in plants processing farm crops should be studied as a system and analyzed by an analog computer to establish maximum efficiency and minimum BOD in the waste.

    A comprehensive study should be made to determine why lagoons work in some situations and not in others.

    Can basic knowledge and technology be extended to further the utilization of processing wastes as livestock feeds and as mulches for gardening? 1977 SMY 8

(Forest Processing Wastes)

** Level of Effort **

Estimated Current - 10 SMY

Recommended FY 1977 - 40 SMY

The importance of continuing protection, development, and use of forest lands for such purposes as recreation, water conservation and supply (all broadly related to environmental quality and its protection) have been emphasized in recommendations of a Forestry Research Task Force. They are extensive and account for a 1977 projected effort of 575 SMY in Research Problem Areas 105, 107, 108, 902, and 904.

The forest products research needs enumerated in this report are concerned with environmental problems arising from the processing operations at sawmills, pulp and paper mills. Process changes are taking place which may change the character and intensity of the problems.

Three principal research areas have been identified with regard to the forest products industries.

Optimal Effluent Management Techniques for Minimizing Interference with Legitimate Downstream Water Uses (i.e., protected by public policy).

1. Optimization of in-process retention of oxidizable organic materials and of external treatment processes through systems analysis procedures; the objective is to develop waste management techniques having lowest economic impact on product value. 1977 SMY 4

2. Development of effective technology for removal of color and residual turbidity from pulp and paper mill effluents. 1977 SMY 8

Optimal Solid Waste Disposal Techniques for Both the Lumber and Pulp/Paper Segments of the Forest Products Industry.

1. Develop procedures for more efficient separation of pulping-quality wood waste from sawmill waste, and for its delivery to pulp mills. 1977 SMY 3

2. Develop technology for pulp and paper mill sludge reprocessing and dewatering that is adequate for producing incinerable solid wastes or usable by-products. Reprocessing involves separation of sludge constituents that would either interfere with incineration, or which may be found to have salvage value. 1977 SMY 6

3. Develop optimal procedures for landfill disposal of sludges and sawmill residues as an alternate to incineration, so as to permit cost minimization and selection of disposal techniques with minimal environmental impact. This suggests an interaction of esthetics, land values and utility, incineration technology problems, and air emission considerations that ultimately lend themselves to systems analysis as input knowledge becomes available. 1977 SMY 4

Adequate Technology for the Kraft Pulp Industry which Will Minimize to a Generally Acceptable Degree the Emission of Undesirable Odors.

1. Investigate improvements in kraft recovery processes to develop better means of attaining chemical and heat recovery without emission of odorous reduced-sulfur organic compounds. 1977 SMY 10

2. Continue to seek new or modified pulping processes which are free of potential odor, or other undesirable atmospheric emission characteristics, and capable of yielding pulps with desired qualities. 1977 SMY 5

Recommended Organization and Level of Research Effort.

It is recognized that a substantial research effort is already being expended by the forest products industry, both through individual companies and on a cooperative basis; the present effort by public agencies is to a lesser degree. Current annual research and development budgets, supported by private industry, for both air and water quality protection-oriented programs probably account for close to $10 million. Program planning ties should therefore be developed with the forest products industry so that newly proposed public agency research efforts can be coordinated with existing programs for mutual benefit.

The basic competence of existing Departmental research facilities, such as the Forest Products Laboratory, and regional and State laboratories, should be evaluated and strengthened where needed. The use of contract and grant programs should be investigated to determine if, and where, Departmental program objectives can be advanced by this route.

The proposed level of effort for 1977 is 40 SMY. It should be noted that the Forestry Task Force has recommended, under Research Problem Area 401, "New and Improved Forest Products" with a 1977 projection of 464 SMY, a research need identified as (n) "emphasis on pollution avoidance or control in the development of products and processes." Further, under Research Problem Area 901, "Alleviate Soil, Water, and Air Pollution" with a 1977 projection of 45 SMY, research needs were noted as follows: (d) "alternative methods of reducing and controlling pollution to levels that are not harmful to man, plants, or animals, or methods that will prevent emission of the pollutant;" (e) reducing pollutants originating from timber-based industries with emphasis on pulp mill operations;" and (i) "developing useful products from wastes to help offset the costs of disposal, and properly emphasizing pollution control as a part of all research on new wood product development."

The recommendations of this Task Force for SMY allocations as shown are believed to be in accord with those of the Forestry Task Force and underscore the necessity of program expansion in the area of processing operations.

In view of the already substantial effort underway within the forest products industry itself, it must be stated that the proposed program

effort will play a supplemental role. It is considered essential, however, that the Department expand its effort in this direction from its present minimal level, in keeping with its objectives of furthering the development of forestry as an agricultural activity through improved opportunities for use of wood as an industrial processing material.

INFECTIOUS AGENTS, TOXINS, AND ALLERGENS

The Problem

The past decade has witnessed the growth of an increasing body of knowledge and concern relevant to the effects of microbiological insults and related biological stress agents on man and animals and the plants on which both are dependent. In general, disease is a manifestation of a variety of insults. Consideration here will be given only to those living agents and their products which may act as allergens or toxicants and are capable of inciting disease in man, animals, and plants associated with the agricultural enterprise.

Source. There are many kinds of infectious agents and carriers of toxins. Any animate or inanimate substance on which they depend for survival serves as a reservoir. Reservoirs for some agents, such as brucellae, are well-known; for others, such as the viruses, they are not well defined. The concurrent outbreaks of neoplastic disease in fish and poultry in different parts of the world in 1960 emphasized the significance of microcontaminants stemming from molds. Tremendous numbers of infectious agents have been characterized taxonomically, but there is a vast deficiency of information about their ecology. For example, the ubiquitous salmonellae may find man, animals, plants, soil, and water as suitable hosts or reservoirs.

Magnitude. Infectious agents and carriers of toxins are disseminated throughout the biosphere. The conditions under which the various agents may induce disease are not fully understood, but range from direct transmission via contact, air, soil, water, food, and intermediate hosts, to indirect transmission. Within a broad spectrum, these agents may be identified as viruses, rickettsiae, bacteria, fungi, and protozoa.

The total impact of infectious agents, toxins, and allergens is difficult to estimate. In animals and plants, there are economic losses through deaths, illnesses, retardation of growth, condemnations, failure to conceive or reproduce, and loss of byproducts. In man, there are illness, suffering, incapacitation, and death.

By far the most common cause of allergy problems stems from the pollens of weeds, grasses, and trees. Most of these are airborne, but they may be transmitted by water. It has been estimated that over ten million work days are lost each year as a result of allergic response to pollens. The annual cost of medical treatment for desensitization to ragweed pollen alone is estimated at $100 million. Other allergens, including those that may stem from infectious agents or their products; i.e., fescue foot, ergot poisoning, and other mycotoxicoses, need further evaluation.

Geographic Distribution. Although infectious agents, carriers of toxins, and allergens are distributed throughout the biosphere, the presence or absence of specific agents is dependent upon ecological influences. Since man has the capability of altering these influences, he must give greater consideration to the total ecosystem if he is to delineate cause and effect.

Physical and Biological Implications. Infectious agents, toxins, and allergens are responsible for vast and undetermined losses in agriculture. Concurrently, some of these exert a direct and serious impact on human health and economy. The eradication of Texas fever (Bovine Piroplasmosis) was readily accomplished once it was factually established that the tick, Boophilus annulatus, was the prime transmitter. Conversely, the control or eradication of the companion disease anaplasmosis continues to plague both cattlemen and researchers primarily because of the numerous vehicles of transmission.

Changes in populations (urbanization) have influenced total agricultural production. Management and production practices have been influenced by socioeconomic demands and the disregard of environmental health. The management of large numbers of animals in restricted areas has magnified problems associated with infectious agents.

Public support for the eradication of animal disease has been greatest where the infectious agents were also transmissible to man. Where agents involved animal species alone, a greater emphasis has been given to control practices such as vaccination or therapeutic drugs. Perhaps this philosophy stems from an ever increasing population that has a declining appreciation of the importance of agriculture to the total socioeconomic welfare.

These trends cannot continue if agriculture is to meet efficiently its future obligations. The public must be apprised of the total worth of research in agriculture. The problems of mycotoxins and salmonellae in our environment are matters of principal concern in food protection, the latter also to each of the livestock groups as a pathogen. Here our concern is narrowly in the area of ecology of the organisms, their dispersion in the environment, and possible ways of eliminating them from the ambient environment of man, livestock, and wildlife. Of particular concern is the problem of eliminating mycotoxins and salmonellae from livestock byproducts, foods, feeds, and from human and animal wastes. Feeds may be, and often are, contaminated by salmonellae from birds and rodents. Ingested wastes from infected calves may cause salmonellosis in other calves, in poultry, in pigs, and other livestock.

State of the Art for Dealing with Infectious Agents and Allergens

All too frequently our efforts to resolve problems have been projected in the emergency context. Stop-gap procedures do not necessarily consider

nor are they compatible with the long range goal. Every effort should be made to coordinate research in a given subject to maximize efficiency toward a sound problem-solving objective.

Excellent progress has been made in several scientific areas such as plant pathology, plant and soil microbiology, and veterinary medicine. However, within all disciplines, greater consideration should be given to the interrelationships of these areas to the total quality of the environment. For example, leptospirosis involves man, domestic and feral animals, and water. We do not know how long the several serotypes of leptospira will survive in water or soil, the conditions that influence survival, the role of aquatic life, etc. Thus, it would seem more rational if research on this problem could be coordinated on an interdisciplinary and, where necessary, an interdepartmental basis to maximize efficiency and objectivity. The same philosophy is applicable to the infectious agents of plants. Examples of the latter are fan leaf of grapes (nemaxvirus) and phycomycosis of grapes which may be spread by contaminated water, soil or plants, and red stile disease of strawberries which may persist in soil for prolonged periods.

The control of plant and animal pathogens that contaminate and survive in the soil continue to challenge the scientific community for effective methodology of control.

There is continuing concern with respect to the widespread presence of broad-spectrum antibiotics in the environment. These antibiotics are used routinely for growth promotion in the feed of young poultry, pigs, and calves. There is also substantial prophylactic and therapeutic use.

Apprehension with respect to current usage is based on information that resistant strains of target micro-organisms emerge in the presence of antibiotics. Concern in this area has increased since the demonstration that antibiotic resistance may be transferred genetically in bacteria to related species or genera in the enteric bacteria group.

This phenomenon, mediated by a Resistance Transfer Factor, may result in the transfer of resistance from an antibiotic resistant commensal such as E. coli to a pathogen such as one of the salmonellae, which may not have been previously exposed to the antibiotic.

Generally the proportion of resistant and susceptible strains of a target organism revert to the original level after the antibiotic is withdrawn from the environment.

Nevertheless, since the same antibiotics are generally used in human and animal medicine, emergence of resistant organisms responsible for zoonoses or anthropozoonoses is a matter of concern. Another concern is over the widespread presence of antibiotics used for prophylaxis or therapy in human medicine and the number of sensitized humans who may suffer severe or even fatal shock upon exposure to such antibiotics.

It is obvious that use in livestock feed and veterinary practice increases quantitatively the hazard directly created by the widespread use of the same antibiotics in human medicine.

It may be desirable to seek antibiotics for specific use in livestock production with others restricted to human medicine. This route might lead to amelioration of the problem but could not produce a solution.

Concurrently, those who are concerned with air pollutants should coordinate their efforts with the soil and water personnel in regard to the allergens. Coordination on an interdisciplinary basis will also assist in determining whether technological advances in specific areas have equally effective application to other areas.

Research Needs

** Level of Effort **

Estimated Current - 197 SMY

Recommended FY 1977 - 270 SMY

Before specific research programs are recommended, studies should be made to identify those problem areas that have the greatest impact on human, plant, and animal health and economy. Consideration should be given to coordinating those areas wherein human health is a factor, with related research programs of the Public Health Service, as well as those of the Department of the Interior and others. This would be particularly applicable to allergens stemming from plant pollens, spores, and those infectious agents common to wild life, domestic animals, and man.

The initial need will be to identify the principal problems and quantify their magnitude. Undoubtedly, greater emphasis would be given to bacterial agents such as salmonellae, leptospira, brucellae, tuberculosis, anthrax, tularemia, and viral agents such as rabies and infectious hepatitis since they all have public health, animal health, and economic implications. The agents responsible for hog cholera, blackleg, vibriosis, coccidiosis, and bovine virus diarrhea do not have direct public health implications, but if uncontrolled, can jeapordize food supplies and the agricultural economy. To fully understand the significance of these agents will entail making full use of existing personnel in regulatory agencies, extension, public health, wildlife, and others to gather essential data.

Direction of these efforts and the compilation of data will require appropriate research personnel. Development of methods for detection and monitoring will require early and intensive research and development. Practical methods for inventorying the virus population are particularly needed. The

proposed efforts to establish a practical program to gather morbidity--mortality statistics of domestic animals by the National Academy of Sciences warrants the fullest support. Following data gathering procedures, major research efforts must be directed toward methods of control of these agents.

Immediate consideration should be given to the development of economically practical methods for destroying pathogenic organisms in liquid and solid animal wastes so that they may safely be utilized in feeds and fertilizers. This will be considered in the portion of this report that is concerned with animal wastes. A controlled lactic fermentation of this waste may serve to eliminate offensive odors, increase palatability and reduce heat requirements for commercial utilization. Much emphasis also should be given to research bearing on biological and ecological control methods such as eliminating intermediate hosts and vectors, vaccination programs, and the development of resistant strains.

Present program procedures have not been oriented toward a comprehensive delineation on these problems. The proposed expansion envisioned in a long range study will not provide a sufficient number of research scientists to solve a significant proportion of these problems solely through their own efforts. However, they should be able to function as a focal point for directing the utilization of existing secondary personnel. The efficiency of these efforts will be greatly enhanced by a coordinated effort with appropriate interrelated programs with the U.S. Public Health Service and other agencies.

It is estimated that several scientists would be required to gather and evaluate the data to initiate this program and that a doubling of scientific personnel would be required within five years and another doubling within ten years. A variety of disciplines should be represented from the start, including a veterinarian, a virologist, a bacteriologist, a microbiologist, a plant pathologist, and an immunologist-allergist.

In addition, basic and applied research on the ecology of infectious micro-organisms in the presence of antibiotics and other commensal organisms will surely increase. Because of its specific relevance to pollution of the environment in relation to agriculture, several scientists preferably at each of five locations where substantial microbiological research relevant to livestock production is underway should be added.

Concurrently, research should be focused on biological, chemical and management methods of eliminating salmonellae from facilities and materials used in livestock production, on vector control, but especially on its elimination from animal wastes.

Current interest in the ecology of pathogens is intense. As noted, transfer of genetic resistance among commensals in the presence of antibiotics has been established. But the problem of microbial ecology in the ambient environment of our livestock, crop, and forest species and of man is hardly touched.

The mass of microbial protoplasm on earth is adjudged to exceed by twenty times that of animal protoplasm. Our knowledge of the interrelatedness of micro-organisms, pathogenic and nonpathogenic, is incomplete. We have for too long considered the pathogenic microbes as separate entities, as if they functioned separately and independently. Much study has been devoted to the physiology and genetics of pathogens within the controlled conditions of the laboratory which may not in fact exist in nature. Therefore, there is much to learn of the ecological influences on pathogenic organisms in the ambient environment if man is to develop methods for their control and concurrently add to the richness and understanding of life.

The survival and possible multiplication in soil and water of pathogenic micro-organisms that may infect plants, animals or man is controlled to a significant extent by the presence or absence of other organisms in that same environment. Nonpathogenic organisms with a close genetic relationship to a pathogen may specifically eliminate the pathogen from an environment. Many soil micro-organisms produce metabolites that are toxic to other micro-organisms. We need to explore the possibilities of using these antagonisms to eliminate specific pathogens from an environment, perhaps by seeding the environment with appropriate competitors and encouraging growth of these competitors.

It has been shown that inoculation of a burn with an appropriate nonpathogenic strain of Staphylococcus can protect this wound from infection by a subsequently inoculated pathogenic strain of Staphylococcus aureus. Somewhat similar competition between strains of Escherichia and Salmonella also have been demonstrated. The possibility of practicing biological control among the microbial population would appear to be a fruitful area for research.

1. A survey and compilation of information on the incidence and magnitude of agriculturally related infectious agents, toxins, and allergens, including costs of damages caused by these pollutants and costs of controlling them. 1977 SMY 22

2. Basic and applied research on the ecology of infectious agents in the presence of antibiotics and commensal organisms with particular emphasis on soil and water environments. 1977 SMY 25

3. Methods of reducing or controlling the level of airborne pollens that are shown to be of major significance as allergens; e.g., ragweed control and breeding of "pollenless" perennial grasses for lawns, pastures, roadside, parks, etc. 1977 SMY 10

4. Feasibility studies on the use of various techniques of eliminating infectious agents and toxins from animal wastes, foods, feeds, and other agricultural commodities; e.g., radiation pasteurization, heat acidification, and combinations of methods. 1977 SMY 16

PLANT RESIDUES

The Problem

Materials remaining as residues from farm and forest production represent great diversity. All farm and forest operations leave residues at point of production. While there are some situations under which residues from field crops and orchards can be used advantageously, there are many cases in which accumulated residues lead to troubles if not disposed of in some way.

In forestry operations, tremendous quantities of logging debris are left each year in the woods; this constitutes one of the most serious fire hazards in forestry and serves to promote spread of tree disease and insect damage. Forest debris in stream channels may increase flood damages by temporarily damming and then breaking. Also, burning of forest debris may cause air pollution. In general, it should be recognized that improvement in silviculture techniques and management practices will reduce logging debris and eliminate cull trees from stands. This reduction in residual material will reduce fire hazard and provide a smaller reservoir for the buildup of insect and disease problems.

Residues from crop and orchard production contribute to pollution in two ways: as a source of particulate material and noxious gases when burned, and as a reservoir for spread of pests and plant diseases.

Although recognized as a source of pollution, burning is the most widely used method of ridding the land of residues. Much of the residues from grass seed production is burned. So are fruit tree prunings, rice straw, barley straw, and dry native range brush.

One reason for the common practice of burning plant debris is that it stops diseases and kills pests. Bacterial, viral, and fungal diseases of potatoes, cotton and apples, as examples, are transmitted through residues left on the farm or at points of storage and loading for transportation. As examples of pests that live and breed in field residues, we may cite: the stable fly in peanut field litter and in rotting hay and straw; the wheat curl mite and wheat streak mosaic in wheat waste; the European corn borer and sugarcane borer in stalks of these respective crops.

The presence of phytotoxic substances in plant residues and soil, and the production of such substances by micro-organisms, may account in part for adverse effects of a particular crop on a succeeding crop in crop rotations, yield reductions, encountered in stubble mulching, citrus and peach tree

replant problems, sod binding in bromegrass, frenching of tobacco, seedling disease of tobacco, the legume bacteria factor in chlorosis of soybeans, and inoculation failure with subterranean clover.

While crop residue mulches often prove useful, in the more humid regions they may depress subsequent crop yields. Unfavorable results may arise from depletion of soil nitrogen, encouragement of weeds, or stimulation of unfavorable microflora.

In the stubble-mulch system, corn in a corn, oats, and wheat rotation may be severely retarded about every three or four years. The retardation is evident in the seedling stage, and the plants seem never to recover fully. The reduced growth presumably is caused by phytotoxic substances in the crop residues or by such substances produced by micro-organisms. Phytotoxic substances have been isolated from stubble-mulched soil.

Landfill is sometimes used as a means of disposing of crop residues. This normally involves more concentrated acreage loading with organic residues than with normal cultivation practices and can, therefore, give rise to problems of localized odor, soil seepage or runoff of putrescible material, or harboring of animal pests unless properly managed.

State of the Art for Dealing with Plant Residues

Plant residues have some useful purposes: bedding for poultry and livestock; source of ensilage, although not widely practiced; mulch for commercial agriculture and gardening; source of organic matter returned to the soil; and limited use in manufacture of boxboard and insulating board.

Research in the 1930's and 1940's in a number of States has proved that proper application of plant residues as mulch cover is effective in controlling wind and water erosion. In arid regions, leaving plant residues on the surface has been found to increase wheat yields.

Stubble from field corn is now largely worked into the soil in preparation for a succeeding crop; in general, this appears to be successful. Corn cobs still find use as a raw material for furfural manufacture. There is also some feed use of corn cobs.

Research Needs

** Level of Effort **

Estimated Current - 20 SMY

Recommended FY 1977 - 50 SMY

The generalized research task is to continue to search for optimal means

for managing crop residue disposal so as to avoid undesirable effects on successive (field) or standing (orchard and forest) crops, local atmospheric environment, and receiving-stream quality.

1. Determine the relationship between the microbial decomposition of crop and forest residues and the effect on plant diseases and insect pest development. 1977 SMY 5

2. Establish optimal procedures for land disposal or other utilization of cleared crop and forest residues; e.g., that from grass seed production, where open burning is found unacceptable because of atmospheric pollution effects. 1977 SMY 7

3. Establish optimal procedures for open burning of plant residues (from a meteorological viewpoint), where farming and forestry practices are found to require such disposal. 1977 SMY 8

4. Encourage further studies of salvage procedures for such residues, such as logging residues, where existing disposal practices (even if managed in optimal fashion) are found generally unsatisfactory. Regarding burning of logging slash, evaluations should be made of the amount and kind of combustion products and of burning modifications to reduce or alter these combustion products. 1977 SMY 6

5. Conduct studies of composting, direct soil incorporation, and surface application to encourage further application of such practices. 1977 SMY 6

6. Conduct studies of livestock feeding of crop residues to encourage further application of this procedure. Dried wastes from leafy vegetables, pea vines, bean vines, and dehydrated cull potatoes, as examples, make good feed components. Beet pulp and citrus pulp became regular commercial feed components. But economics in the past era, with environmental problems less severe and with less pressure to conserve food and feed, worked against development of feedstuffs from a variety of agricultural discards. Studies should also be carried out to show how ground corn cobs fit in well as carbohydrate roughage component along with molasses and urea in the newer type of feed mixture. 1977 SMY 6

7. Develop new data on improved methods of employing plant residues as mulching materials. 1977 SMY 6

8. Conduct studies on total harvesting; e.g., (1) of the entire corn plant, including field processing for feeding purposes and (2) of the entire tree, including residue conversion into chips for return to the site. Development of harvesting machines for this purpose and of handling procedures should go far in relieving cost problems now connected with field residues. 1977 SMY 6

It should be clear that the outlined research problems lend themselves to systems analysis, as far as justification, planning, and evaluation of research is concerned. The residues may be viewed as the center of such a system, in which optimization of their disposal is sought for each particular agricultural practice where disposal problems have been recognized. This suggests that such studies could best be pursued by their incorporation into existing commodity crop or forestry management programs where they already receive some attention.

SEDIMENT

The Problem

Sediment as a Pollutant. Sediment is the perfect example of the definition of a waste as being a resource out of place. Sediment has a bilateral effect. It depletes the land resources from which it is delivered, impairs the quality of the water resources in which it is entrained and degrades the location where it is deposited.

Sediment comprises the undissolved solid particles carried from their sources by wind and water, and deposited in streams, lakes, or estuaries and on lands at varying distances from the sources. Most sediment consists of soil and rock particles eroded from disturbed lands: crop, range and forest areas; highway rights-of-way; surface-mined areas; stream banks; and suburban construction sites. A small percentage of erosion sediments consists of bits of organic debris. Limited amounts of sediment may also be derived from fly ash and from industrial operations and waste effluents.

Sediment becomes a pollutant when it occupies water storage reservoirs, fills in lakes and ponds, clogs stream channels, settles on productive lands and interferes with their use, destroys aquatic habitat, creates turbidity that detracts from recreational use of water, as well as when it degrades water for consumptive or other use, increases water treatment costs, or damages water distribution systems. In addition, sediment is a carrier of other pollutants.

Mechanics of Movement. Separation from their sources of the varied materials that become sediments may be accomplished by gravity, frost-heaving, temperature expansions and contractions, raindrop splash, scouring wind and running water. Activity of these natural agents is increased by the numerous activities of man that remove the protective cover and disturb the soil. Transport of the separated particles may be wind or water or gravity. We will address ourselves here to sediment carried by water. Airborne dusts are discussed in the chapter entitled "Airborne Chemicals and Particulates."

Magnitude. Sediment derived from land erosion constitutes by far the greatest mass of all the waste materials arising from agricultural and forestry operations. Committee Print No. 9 of the Senate Select Committee on National Water Resources states:

> "Rough estimates of the suspended solids loadings reaching the Nation's streams from surface runoff show these to be at least 700 times the loadings caused by sewage discharge."

In an average year, approximately 450 million cubic yards of material are dredged from U.S. rivers and harbors, much of which is removal of sediment in order to maintain the navigation channel.

Erosion by surface runoff produces some four billion tons of sediment each year, and of this total one-fourth is transported to the sea. About three-quarters of the sediment comes from agricultural lands, where water erosion is the dominant problem on 179 million acres of cropland and a significant problem on an additional 50 million acres.

Source and Distribution. The sediment burden in streams may come from many different sources through the erosion process. It arises from forested lands that have been devastated by fire, construction of forest roads and other forest improvements, certain logging practices, over-grazing and trailing of animals on rangelands, cultivated lands that are improperly treated or inadequately protected, industrial construction sites, highway construction, unprotected roadside cuts, suburban development projects, spoil banks from strip mining and other mining activities, unstabilized stream banks, and geologic erosion of such areas as the Badlands of South Dakota. The land is robbed and the water despoiled.

The material is entrained by water in motion, transported by moving water, and deposited by relatively quiet or still waters.

Occurrence of erosion and significant sediment production on a great part of our cropland has already been noted. Other significant sources of sediment will be briefly discussed.

Erosion along highways: Erosion along primary, secondary, and tertiary highways is extremely active where protection from it has not been provided. During highway and road construction activities the land surface is vulnerable to erosion. It has been shown that such disturbance in Scott Run Watershed, Fairfax County, Virginia, has produced sediment at the rate of some 89,000 tons per square mile per year at the source and about one-half this amount was measured downstream at the gaging station. The average sediment yield for an average storm even in highway construction areas was found to be about ten times greater than for cultivated land, 200 times greater than for grass areas, and 2,000 times greater than for forest areas. Erosion losses measured from bare roadside cuts near Cartersville, Georgia, ranged from 185,000 tons per square mile per year to 27,500 tons per square mile per year depending upon the rainfall, the degree of slope and the exposure of the bank. Comparable rates were found on road cuts in the Baltimore areas.

Sediment from areas undergoing construction: Construction activities involved with urbanizing areas give rise to similar rates of sediment production. Rates per unit area vary tremendously depending upon the size of the drainage areas. On a small construction site at Johns Hopkins University, encompassing about 1-1/2 acres, a sediment yield rate of

140,000 tons per square mile per year was measured. To illustrate the high sediment yields from areas undergoing construction, the watersheds above Lake Barcroft, Virginia; and Greenbelt Lake, Maryland, contributed peak yields of 25,000 tons per square mile and 10,000 tons per square mile annually.

Streambed and streambank erosion: Erosion is a serious problem on at least 300,000 miles of the Nation's streambanks. Because the banks of the streams and rivers are essentially a part of the water and sediment conveyance system, material eroded from these banks is immediately available as damaging sediment. Recent surveys of the intermountain region of the Western United States indicate that 66 to 90 percent of the sediment production of many of the streams comes from streambank and streambed erosion.

Strip-mined lands: Approximately 2.3 million acres of sediment-producing surface or strip-mined lands exist in the United States and are critical sources of sediment and other mine wastes. The greatest portion of these many acres are abandoned with little or no provision available to apply the basic reclamation measures needed to alleviate the conditions that are contributing to the detrimental off-site conditions. Studies made in southeastern Kentucky indicated that sediment yields from coal strip-mined lands can be as much as 1,000 times that of undisturbed forestland. During a four-year period the annual average from Kentucky spoil banks was 27,000 tons per square mile while it was estimated at only 25 tons per square mile from adjacent forested areas.

Storage capacity of reservoirs: Storage capacity of artificial reservoirs in the country is being depleted at the rate of about one million acre-feet each year by the deposition of sediment. This damage is reflected not only in the loss of storage capacity for water supply, flood control, power generation, navigation and regulation of streamflow for water quality control, but also in its impact on these facilities for recreation.

Recharge of aquifers: The presence of suspended sediment in water being used to artificially recharge underground aquifers presents problems by clogging the aquifer pore spaces, and costs are incurred to clear the water before it can be used for this purpose.

Sediment is produced everywhere because gravity and wind and water act everywhere; though the amount varies with the climate, the slope of the land, the structure of the soil, and the use and management of the land.

Trends. Methods of preventing erosion and sedimentation are known and are being applied to most source areas and causes; however, there remains much to be done to control old sources on crop and rangeland and on unreclaimed mined lands. Although protective measures are being applied for protection of denuded sediment producing areas in suburban development and in road and highway construction, the rate of expansion of the highway network and of growth of towns and cities is such that we are barely keeping even with

the increase in the problem. We are a long way from attaining the reductions in sediment production and movement that could be made with present knowledge; even at best we could not expect to stop all of it. We will always have some sediment to contend with here and there; for a long time yet it will represent a major problem.

Physical and Biological Implications. Aside from filling stream channels, irrigation canals, farm ponds, and reservoirs used for irrigation, recreation, fishing, and farmstead water use, sediment in water increases the expense of clarification of the water used on the farmstead or in sprinkler irrigation systems. Suspended sediment impairs the dissolved oxygen balance in water and thereby slows amelioration of other oxygen-demanding wastes. Reduced oxygen supply hurts fish life. Fish population is also reduced by the sediment blanketing fish nests, spawn, and food supplies. The thousands of farmers using farm ponds to sell fishing rights are much concerned with the deterioration of water quality by sediment burden.

The useful life of many farm ponds is surprisingly short because of sediment accumulation. Surveys on 30 farm ponds in the Iowa and Missouri Deep Loess Hills land resource area showed that, on an average, they would be completely filled with sediment in 20 years. However, the ponds will have been rendered essentially useless, and many will have become a nuisance, long before their original water-storage capacities have been replaced by sediment.

The adverse effect of waterborne sediment upon agriculture is by no means limited to losses associated with recreational use of farm and ranch ponds. Damage to agricultural land resources from overwash of infertile materials, impairment of natural drainage, and swamping and increased flooding because of sediment accumulations in stream channels are also aspects of the silt problem having a direct bearing on farmers and ranchers. Irrigation canals and waste water disposal ditches are also subject to costly maintenance because of silt deposited from muddy water.

Potable water must be free of sediment. Many industrial uses, for example, food processing, require sediment-free water. Sediment deposited in condenser tubes used in industrial cooling may cause costly incrustations. Cost of clarifying water increases with degree of turbidity. High turbidity of water adds costs through the need for greater use of chemicals as flocculants, and more frequent cleaning and disposition of silt from settling basins.

People like clean water for swimming and other recreational activities.

Fine suspended sediment has caused heavy losses of commercial fish and shellfish yield from both inland and tidal waters.

Coarse sediment passing through power plants has caused serious abrasion of turbine blades.

Deposition of sediment in stream channels or aggradation of flood-plain lands may impair drainage and cause channels to overflow more frequently. Since sediment increases the volume of the flow which carries it, floodflows carrying high sediment loads inundate a much larger area than comparable flows free of sediment. Floodborne sediment may damage growing crops and sands, gravel, and other coarse debris deposited on fertile alluvial soils may reduce their productivity.

Reduction of reservoir storage capacity is another devastating consequence of sediment. About one million acre-feet of sediment is deposited in artificial reservoirs of the United States each year. Loss of reservoir capacity to sediment has particular implications for programs of water resources development because reservoir sites are limited. Indeed, prevention of such losses is a primary justification for land treatment measures and watershed protection programs in many upstream tributary areas of the country.

Estuaries, bays, and coastal harbors tend to become vast sediment traps where continuous dredging and other operations are required for handling sediment. Comingling of fresh sediment-laden water and saline water, plus the influence of tides, waves, currents, and shipping traffic, complicate the depositional processes in such coastal areas, and we should recognize that sediment is a major contaminant of these areas.

The biological impact of sediment, however, arises in the main from the materials transported by sediment: adsorbed toxic and nutrient chemicals, some radioactive materials and some pathogens. Direct adsorption on sediment particles and biologic metabolism of nutrients carried by sediment may reduce available oxygen in water, and so affect aquatic life.

State of the Art for Dealing with Sediment

Technology is currently available to permit reduction in the movement of sediment. However, there is no reason to expect this technology to be put into practice to the extent that sediment movement will be largely eliminated. Hence, sediment will continue to be carried in moving water and will carry with it various available pollutants. It is primarily the larger sediment particles that are most readily controlled by available technology; but it is the fine particles that are the principal carriers, the most active chemically, and transported farthest before deposition. We do not yet have adequate controls for the clay and colloidal fractions which make up the bulk of the sediment problem both at source and in final deposition.

Stabilization of the sediment source by proper erosion control measures is the most direct, and usually the most satisfactory, approach in dealing with most sediment problems. Such erosion control practices are multi-beneficial by preserving land and vegetation resources and at the same time reducing sediment yield. Where the sediment is derived from sheet

and rill erosion on agricultural, forest or range lands, certain agronomic and forest and range management practices as well as mechanical and structural measures effectively reduce sediment yields. For instance, changing cultivated fields from row crops to small grain may reduce soil loss due to sheet erosion by from 60 to 90 percent, depending on cover conditions, oils, and seasonal distribution of rainfall.

Rotation of crops to include meadow in the cropping sequence may reduce average soil loss from fields by 75 percent. Such practices as mulching, strip cropping, and contour cultivation have been shown to be highly effective in reducing soil erosion on farmlands. Graded cropland terraces may reduce erosion on fields by 75 percent and in combination with crop rotations, mulching, minimum tillage, etc., can reduce to practically nothing soil loss from cultivated cropland fields. Converting cropland to good grassland, pasture, or woodland can reduce soil erosion by 90 percent or more.

Methods are known for controlling excessive sediment arising from construction activities, including both new highways and industrial and urban developments. The treatment of existing, unprotected surface-mined lands can be accomplished by basic reclamation of these lands. The control of streambank and streambed erosion usually requires emphasis on structural measures. Grade stabilization structures, riprap of stream banks, the installation of jacks to induce deposition, and the sloping and vegetating of eroding banks are among the types of measures used.

There is ample evidence to support the claim of reducing sediment yields by the measures now in use. Agronomic and supporting mechanical field practices have reduced the amount of sediment reaching reservoirs by amounts ranging from 28 to 73 percent. Good conservation practices on cultivated watersheds have reduced sediment yields by almost 90 percent. The protection of existing forest and range lands indicate such measures may reduce sediment yields by 90 percent. Streambank protection work on Buffalo Creek, New York, reduced sediment delivery to Buffalo Harbor during flood flows by 40 percent. It is anticipated that the sediment yield from logging operations in the Middle Fork Eel River, California, will be reduced about 80 percent with proper planning and management.

Research conducted on many different soils varying in characteristics, slope, cover, and prevailing climatic conditions provided a mass of empirical data on soil loss as induced by rainstorms. The data were subjected to complex mathematical analysis by a digital computer which enabled the formulation of a universal erosion equation. This equation aids action agencies to predict what soil losses will be on a given soil of specified slope, under varying cropping conditions, with a given rainfall energy input.

Watershed research has shown that land cover is the major deterrent to sediment delivery into tributary streams. Extensive empirical information has been accrued on the entrainment, transportation, and deposition of

sediments in the upstream watersheds towards making valid predictions of sediment accumulation behind flood-detention structures.

Improved technology in logging and construction of forest roads has reduced sediment delivery from forestry operations.

Forestry research on the abatement of wild fires has made a major contribution in diminishing sediment delivery from forested lands. Soil loss from a burned area is frequently tremendous.

Criteria for engineering design of sediment traps and debris basins could stand much improvement.

There needs to be a much better understanding of sediment transport in tortuous upstream tributaries, with emphasis on better understanding of the hydraulic forces necessary for design and maintenance of stable stream channel systems.

Limited information is available on the role of sediment as a transporting agent for pesticides and other chemicals.

Since comprehensive river basin planning is moving forward rapidly under the leadership of the Water Resources Council, expansion of effort to gain new or better information and technology on sediment problems in upstream watersheds should keep pace.

Research Needs

** Level of Effort **

Estimated Current - 96 SMY

Recommended FY 1977 - 254 SMY

Reduction of the rate of accelerated erosion is the only positive and permanent cure for the sediment problem. However, the development and widespread application of land management practices to control all erosion is a dream of the future and specific measures for transporting, storing, or otherwise handling sediment and the materials it carries will be required in many situations. But before development of more acceptable land use practices can be effectively pursued, increased knowledge of the erosion processes and definition of the basic principles governing the movement and loss of soil must be attained.

Sediment Per Se

1. Increased knowledge of erosion processes to better define the basic principles governing the movement and loss of soil. 1977 SMY 32

2. Better concepts and procedures for identifying critical sediment source areas and predicting sediment delivery from such areas as affected by natural and man-induced environmental conditions. 1977 SMY 28

3. Improved and more complete criteria for the design of sediment traps and debris basins. 1977 SMY 21

4. Improved control practices integrated into systems that will reduce runoff and provide for the safe removal of any excess drainage water. 1977 SMY 73

5. Additional information on the rates and processes of sediment deposition in reservoirs and water detention structures, on floodplain lands and in estuaries and harbors. 1977 SMY 26

6. More effective and economical techniques for stabilizing streambanks. 1977 SMY 23

7. New technology to stabilize eroding soil in developing urban areas, on roads and highways and on other construction sites. 1977 SMY 8

Sediment as a Carrier of Pollutants

1. Demonstrating the feasibility of using grassed waterways, of diverting cropland runoff and highway drainage onto sod-forming crop areas or woodlands; to provide and measure the effectiveness of these organic filters and traps for sediments and other pollutants before the drainage waters reach streams or ponds or lakes. 1977 SMY 5

2. Determining the rate of chemical and biological breakdown of the various kinds of pollutants adsorbed on sediment particles and identify environmental conditions under which the rate of breakdown can be enhanced. 1977 SMY 15

3. Determining the kinds and quantities of plant nutrients carried from agricultural and forest lands in eroded sediments and their organic fraction, and how this loss can be reduced. 1977 SMY 9

4. Identifying the kinds and quantities of pesticides and other pollutants carried from agricultural and forested lands in eroded sediment and their organic fractions. 1977 SMY 12

Economic Research Involving All of the Above Topics

1. Determining the costs of controlling this pollution at the source, while in transit, or at the point of deposition. There is a correlated need to assess the advantages that would accrue to society by controlling these pollutants at each of these three points in the system. 1977 SMY 2

PLANT NUTRIENTS

The Problem

Plant nutrients are normal constituents of fertile soils. They are vital in the production of food and fiber. Occasionally, some nutrient can be added or accumulate to a sufficiently high level to become a soil contaminant.

Altogether too prevalent is the movement of plant nutrients into streams, lakes, and reservoirs, where they then enable the growth of unwanted algae and water weeds. Nitrogen is almost always present in sufficient quantity to permit algal blooms. On the other hand, phosphorus is very often the factor-limiting growth, even though only 1/50 part per million is the threshold for growth. Thus, movement of even very small amounts of phosphorus into waters may lead to unwanted plant growth.

Millions of tons of fertilizers and soil amendments are added to lawns, ornamentals, orchards, forests, and croplands each year. Even though rate of fertilizer usage in the United States is very low compared to that in European countries, chemicals applied to the soil become prime suspects when the unwanted effects of plant nutrients are evaluated. Nutrients are also added to croplands by precipitation; normal biological activities in soils and on the roots of plants; and by applications of organics such as animal wastes, crop residues, and sewage residues.

Plant nutrients enter into water from precipitation, municipal sewage, industrial wastes, and runoff from feedlots, barnyards, and agricultural land.

Sewage delivery is the main source of unwanted plant nutrients available for undesirable growths in surface waters, since two to four pounds of phosphorus are delivered per year per person in the sewage system. Four pounds of phosphorus dissolved in 30 acre-feet of water will readily enable algal growth.

Every 1,000 tons of sediment moving into a stream carries an average of 1,000 pounds of phosphorus. Most of this phosphorus is tightly held on clay particles and is unavailable for plant growth.

Plant nutrients in soils accumulating to the level of contaminants can adversely affect or kill economic plants. Boron is present at toxic levels in several areas of the San Joaquin Valley in California. Phosphate fertilizers may be added in such level as to seriously harm plants by inducing

zinc or iron deficiency. Potash applications have induced serious magnesium deficiency conditions.

Excessive growth of water weeds stimulated by the presence of the essential nutrients -- the process of eutrophication -- results in serious oxygen-depleting pollution when the plants die and decay. Low oxygen levels bring on fish kills. Disagreeable odors develop that detract from municipal and recreational uses.

Nitrate in drinking water can cause methemoglobinemia in babies (blue babies). It also may be toxic to ruminant livestock. The biochemical status of a baby's stomach or that of a ruminant readily reduces nitrate to nitrite. Nitrite acts on hemoglobin and impairs its oxygen-carrying capacity by formation of methemoglobin.

The Public Health Service has recorded its concern for the number of cases of "blue babies" found in rural areas using wells for drinking water.

Accumulations of nitrate in forage entering into ensilage may release noxious nitrogenous gases on fermentation. Nitrate may accumulate to high levels in leafy vegetables such as spinach.

State of the Art for Dealing with Plant Nutrients

Farmers in the United States spent about 1.5 billion dollars for purchased chemical fertilizers in 1966. It contained 6,049,000 tons of nitrogen, 4,330,000 tons of phosphate (P_2O_5), and 3,624,000 tons of potash (K_2O).

Significant amounts of the purchased fertilizers are applied to lawns, golf courses, parkways, and ornamentals. Average rate of nitrogen application to crop land in 1966 was about 30 pounds per acre. On many crops, application of nitrogen ten times this amount would be essential to maximize yields.

We do not now need such increased yields and present prices would not justify them. By the year 2000, our expected 300 million people may well need such production. We had best get the necessary research underway to: (1) most efficiently and economically use the applied fertilizer; and (2) minimize the burden of eutrophication in lakes and streams, and the hazard of excess nitrate in our drinking water that would result from leaching or washing these nutrients from soil where applied into aquifers, lakes, and streams.

Although field studies show that much higher levels of fertilizer application are now economically justified in many instances, it is probable that less than half of the total now applied is effectively used by plants. Over-application in numerous instances, poor scheduling of applications,

inadequate application procedures, and poor nutrient balance result in excessive or luxury consumption by economic plants, excessive leaching or loss by runoff, and volatilization into the atmosphere. Improved technical information for different soils, under different climates for different crops could avert as much as one-half of the loss from non-beneficial use of this fertilizer. This possible economic gain to the farmer is over and above the gain from averting adverse effects of plant nutrients that move into surface waters, ground waters, feeds and foods, or the atmosphere.

Research Needs

** Level of Effort **

Estimated Current - 200 SMY

Recommended FY 1977 - 275 SMY

Activities should be expanded to develop technology to greatly improve efficiency of use of applied fertilizers while minimizing movement of residual fertilizer components into the area of environment contaminants.

1. Fertilizer practices that will maximize marginal returns from purchased inputs while minimizing:

    a. Accumulation of some nutrients to contaminant or adversely effective levels;

    b. Accumulation of excessive levels of nitrate in feed and food plants;

    c. Tendency of nitrate to move into ground water;

    d. The movement of phosphorus and other plant nutrients into surface waters from subsurface drainage or surface runoff; and

    e. The volatilization of applied nitrogen fertilizers as unidentified substances that may add to air pollution from nitrogen oxides. 1977 SMY 220

2. Phosphorus and other nutrient content of runoff from agricultural and forested watersheds. This information is needed in specific relationship to the geochemical attributes of the solum, stratigraphy, chemical applications, cultural practices, cover and hydrologic conditions. 1977 SMY 15

3. Chemical behavior of phosphorus attached to sediment as affected by changes from oxidative to reducing conditions and vice versa. 1977 SMY 12

4. Extent and manner in which nitrate in ground water comes from sewage or septic tank effluent, feedlots or barnyards, field fertilization, or the natural accumulations such as found in the caliche of semi-arid regions. Much of the available information is inconclusive or contradictory. 1977 SMY 10

5. Sources and modes of transport by which nitrate moves into ground water. 1977 SMY 10

6. Costs and returns of using different fertilizers in the production of crops in relation to their appearance in runoff drainage waters. All alternatives should be considered, especially the use of barnyard manure versus chemical fertilizers. It appears that one of the major tasks confronting the economist with this type of pollutant is that of informing the public as to the costs and benefits of controlling the pollution. 1977 SMY 8

MINERAL AND OTHER INORGANIC SUBSTANCES

The Problem

A wide variety of naturally occurring and manufactured substances such as inorganic salts, metals, metal compounds, acids and alkalis may act as pollutants.

Over 3.5 million tons of sulfuric acid are annually delivered by mines into streams. Although the amount of acid delivery has decreased over the past two decades, concern over the problem has appreciably increased.

Salts are normally formed in the degradation of geologic materials as well as being a component of geologic depositions; e.g., the salts in the Mancos shales of Wyoming. The accumulation in soils, under arid or semiarid conditions, is due to the high level of potential evapotranspiration in relation to rainfall.

By runoff and subsurface movement these salts enter into surface streams. For example, the Colorado River at Yuma, Arizona, carries 1.2 tons of salt per acre-foot of water. Average annual flow of the Colorado is about 15 million acre-feet per year. Even the Susquehanna River in the Eastern United States delivers 11,500,000 tons of salt per year, but dilution averts adverse effects.

The chemical and metalurgical industries may release substantial quantities of these substances into streams in sufficient levels to not only kill fish but most all biota.

Lead may reach contaminated levels in soils (a) by application of limestone containing this element as an impurity; (b) by application of lead arsenate as an insecticide; (c) as "fallout" from automobile exhaust; and (d) deposition from the stock effluent of industrial smelters.

Mercury may accumulate to contaminative levels in soils by repeated applications of mercury containing fungicides.

Soils contaminated with heavy metals may permit movement of these substances into food plants appreciably above the "safe level" as prescribed by law. Arsenic has accumulated in orchard soils to toxic levels by past spraying with lead arsenate.

Cadmium has been found at contaminant levels in some soils. Some sources of phosphate contain appreciable cadmium as an impurity.

Acid mine drainage kills fish and spoils water for domestic, livestock, irrigation, and recreation uses. Agriculture and forestry have an interest in the elimination of this problem.

A farmer in the Imperial Valley, California, applying a five-foot depth of Colorado River water to his fields over a year's time also applies six tons of salt per acre.

For an irrigated area to survive, a favorable salt balance must prevail. As much or more salt must be removed by deep percolation or drainage as that added by the irrigation water. Otherwise, salt accumulates in the soil to levels that inhibit or prevent growth of economic plants.

Under irrigation, 50 to 80 percent of the applied water is consumptively used in evapotranspiration. Water evaporated is pure water. Its former content of salt is left in the soil. Salt content of drainage water must appreciably exceed that received from the irrigation ditch if soil contamination is to be prevented. Thus, it is that irrigation agriculture is accused of polluting the water in the return flow. Agriculture merely uses the water in natural biological processes and passes on the salt received in such water.

Of the 30 million acres of irrigated land in the 17 Western States, about one-half of this acreage is subjected to the hazard of salinization, and crop production is definitely impaired on about 20 percent of this acreage.

Federal reclamation projects in 1966 provide an on-farm cash value of crops produced as $211 per acre. There are about 30 million acres of irrigated land in the 17 Western States (eclamation States). Thus, the irrigated acreage in these States produced crops having a total on-farm value of about $6 billion. Yield is impaired or eliminated by salinity on about one-fourth of the irrigated acreage (7 million acres); i.e., production is only 50-60 percent of potential due to salt contamination. These afflicted acres could have produced crops under minimum salinization to the value of $1.5 billion. Actual value of the crops on the salinity afflicted land was only about $800 million, a loss of $700 million in productive potential including beneficial use of irrigation water.

State of the Art for Dealing with Mineral and Other Inorganic Substances

The Public Health Service estimated in the early 1930's that 2.7 million tons of sulfuric acid were produced annually by mines and delivered into tributary streams. Although the amount of acid delivery from mines has decreased, awareness of the problem has increased. Acid mine drainage kills fish and spoils water for domestic, livestock, irrigation, and recreation uses. Agriculture and forestry have an interest in the elimination of this problem.

Salinity is a hazard on about half the irrigated acreage in the Western States. Crop production on one-quarter of this acreage is already impaired salt-affected soils. Production is threatened in irrigated projects the world over.

The trend toward intensified use of limited irrigation water resources foreshadows more severe problems in the future. Irrigation projects must generally maintain salt balance. Salt cannot accumulate in the soil without damaging crops, so as much salt must be carried out in drainage water as is applied in irrigation water. The decrease in volume of water with each use results in a proportional increase in salt concentration. Thus, if 20 percent of the total water flow in a river is consumptively used by each of four successive projects along the river, the relative salt concentration of the river will increase from 1.0 to 1.25, 1.67, 2.50, and 5.0 following each stage of use and return flow.

It is obvious that as the river flow is depleted, the salt concentration of the remaining flow must increase inversely with the volume of water if salt balance in all projects is to be maintained. It is further obvious that, under salt balance conditions and with return flow of drainage water, complete allocation of the river flow may give the last project a water with prohibitively high salt content.

Over the past couple of decades, research has enhanced the capability of coping with salt problems affecting agriculture.

Improved procedures for evaluating water quality for irrigation have been developed, using electrical conductivity as the primary criterion and sodium-absorption-ratio as the secondary criterion.

Far better standards have been developed for leaching procedures in the reclamation of soils and for leaching requirements during continued management.

Much advancement has been attained in understanding the physico-chemical behavior of salt-affected soils.

Since water is the vehicle by which salt moves in soil, an understanding of the physical principles of water movement is absolutely essential. Excellent progress has been made in measuring the energetics of water retention and movement in soils.

Good progress has been made in characterizing the salt tolerance of important crop plants.

There is a real need to develop better means of assaying salty-soil problems as related to characteristics of irrigation waters. The relationships are very complex, and oversimplification can lead to poor technical guidance.

Recent advancements in making key measurements on the physical forces involved in soil water must be exploited towards far better appraisal of field conditions related to water.

There is an increasing need to attain an understanding of the biochemical and physiological mechanism in plants that determine their tolerance to various salt-affected soils. The role of climatic conditions in modifying these mechanisms also needs clarification. There is an urgent need to develop crop varieties higher in salt tolerance. An understanding of basic mechanisms in each important species would obviate the present superficial approach of cut-and-try testing.

The management practices that may be followed in an irrigated field that is subject to salinization need far better quantitative characterization.

Hard experience in the Western States has shown that successful irrigation requires effective drainage. Accumulating salts must be continually leached out. Excessive leaching wastes water and nutrients. There is an urgent need to develop and test better mathematical expressions for the calculation of leaching requirements, drainage requirements, and the proper salt balance that ought to be maintained.

Research Needs

** Level of Effort **

Estimated Current - 44 SMY

Recommended FY 1977 - 95 SMY

1. Developing and evaluating alternative procedures for the disposal or reclamation of irrigation return flow. These procedures must seek to maximize beneficial use of water available, while minimizing adverse effects to downstream users. 1977 SMY 25

2. Developing procedures and management practices for using water of impaired quality in the economic competition for scarce water (irrigation agriculture does not stand high on the totem pole). 1977 SMY 20

3. Developing crop plants that have high tolerance to soils contaminated with salts or alkalin. This objective has vast implications on the burgeoning demands on world food--a stress that is especially prevalent in arid and semiarid regions. 1977 SMY 30

4. Preventing acid mine drainage from moving into surface streams. <u>1977 SMY 8</u>

5. Economically counteracting the adverse effects of accumulations of heavy metals in soils. <u>1977 SMY 8</u>

6. Assessing the extent of damages to agricultural production and computing the economic hazard to the producers. The cost of alternative methods of control should be calculated, with special consideration given to economic incentives needed to encourage the control of these pollutants at the source, i.e., tax write-offs, etc. <u>1977 SMY 4</u>

PESTICIDES

The Problem

In the control of pests large quantities of pesticides are introduced into the environment. The selection of materials for use and the manner in which they are applied are predicated upon such factors as (1) the degree of protection required, (2) the pest to be controlled, (3) the period of time for which control is necessary, (4) the severity of the infestation, and (5) the economics of various control alternatives.

Some of the materials used disappear very rapidly while others may persist for a considerable period of time. The more serious problems are created by the use of certain persistent insecticides and herbicides. Of less importance are rodenticides, nematocides, dessicants, defoliants and fungicides.

Other sources of environmental contamination are residues left in empty containers (such as paper bags, cans, and fiber drums) and wastes from the manufacturing and formulating process, particularly from smaller installations.

Certain persistent insecticides exemplify our most serious contamination problems as they tend to concentrate in biological systems and upset ecological balances.

One of the most important responsibilities of agricultural research is to develop and facilitate the use of methods and materials for the control of pests. These research programs are expected to make continuing progress in the never-ending struggle to protect man, his food and fiber supply, and his forests from the ravages of pests. Such protection is essential if the American people are to continue to enjoy their present high standard of living and if this abundance of quality food and relative freedom from the hazards of pests is to be enjoyed by all mankind.

In protecting man, animals, plants, farm and forest products, communities and households against depredation by pests we must have continuing concern for (1) the health and well-being of people who use pesticides and those who use products protected by them; and (2) for the protection of fish, wildlife, soil, air and water from pesticide pollution.

In keeping with this concern we must encourage the use of those means of effective pest control which provide the least potential hazard to man and animals. When residual pesticides must be used to control or limit pests, they should be used in minimal effective amounts applied precisely to the

infested area and at minimal effective frequency. Biological, ecological or cultural methods or nonpersistent and low-toxicity pesticides should be used whenever such means are feasible and will safely and effectively control or eliminate target pests.

Considerable concern has been expressed by ecologists and wildlife specialists over the ubiquitous occurrence of certain pesticide residues in our environment. Residues of these materials in various stages of degradation have been found at locations far from the original point of application. In some instances, these residues have tended to concentrate in food chains.

It is apparent that the fate of pesticides should be traced through the intricacies of the ecosystem. For example, there is little information on the transport of pesticides through the air or to bodies of water. Efforts have been concentrated largely on determining the decline and fate of pesticides at or near their point of application.

State of the Art for Dealing with Pesticides

During the past five years, the use of pesticides has greatly increased. A wider choice of materials on the one hand and the improved application techniques on the other have permitted this increase without a corresponding increase in residues - as borne out by the Market Basket Survey of the Food and Drug Administration, the soil and water monitoring programs of the Department of Agriculture, and the monitoring of pesticide concentrations in humans by the Public Health Service. However, the extensive monitoring program of the Fish and Wildlife Service and others presents clear evidence that certain persistent pesticides are widely distributed in our environment. There is also evidence that buildups in concentration of these materials do occur in certain food chains and natural systems. The nature and significance of these buildups is of great concern to a scientific community concerned with the integrity of ecosystems. Additional research is urgently needed to clarify these areas of concern.

Total elimination of the majority of pollutants from the environment is not possible. This has necessitated the establishment of standards to define uses to which a contaminant may be put without undue detriment to some other resource or use. The Presidential Science Advisory Committee report, Restoring the Quality of Our Environment, states with regard to standards, "In order to balance the advantages of a control effort against possible economic disadvantages one should know the whole spectrum of effect of a pollutant." Where the origin of the problem is widespread, as in this case, its solution may depend on simultaneous attacks -- some of which may be uneconomical -- at several different points. This can only be accomplished after acquiring a comprehensive understanding of a pollutant's disposition throughout the environment.

Research Needs

** Level of Effort **

Estimated Current - 1743 SMY

Recommended FY 1977 - 1753 SMY

Public-supported research is necessary to complete our understanding of how presently available materials pass through the various components of our environment, their relationships and combination with other compounds, and their ultimate fate. It appears that this will be completed within the next ten years, if the National Program of Research for Agriculture plans are carried out as scheduled. Industry is now required to develop this type of information for new materials as a prerequisite to their registration.

1. Minimizing the need for using materials which contaminate the environment in large-scale pest control programs. 1977 SMY 958

2. Developing equipment and application techniques whereby less material will have to be used to achieve control and the material can be placed only where it is needed. 1977 SMY 45

3. Refinement of integrated control systems whereby a combination of biological, cultural, and chemical forces can be used in a complementary relationship. 1977 SMY 500

4. Developing capabilities for predicting and minimizing buildups in pest populations. 1977 SMY 20

5. Determining the fate of pesticides in plants, animals and their products and in the environment. 1977 SMY 200

6. Determining the feasibility of using detoxifying or binding agents to prevent the release of pesticides from soil to crops growing in it. 1977 SMY 5

7. Investigating the capabilities of microbial degradation of pesticides and developing methods for utilizing this phenomenon. 1977 SMY 10

8. Identifying and evaluating chemicals which accelerate the physiological elimination of pesticide residues by livestock and other animals. 1977 SMY 5

9. Determining the highest populations of well established pests that are consistent with public interests (for instance, in the case of a crop, the highest pest level which is consistent with economic production of the crop, or in the case of a disease vector, the highest level at which the danger of disease transmission is acceptable). 1977 SMY 5

10. Determining the optimum pest populations in terms of economically maintaining that level by integrating biological, natural, chemical, and other control measures. 1977 SMY 5

The research areas in which the greatest contribution could be made in the immediate future are probably those of improving application equipment and application techniques. This could result in reducing (1) quantity of pesticides needed for control, (2) hazards to fish and wildlife, and (3) runoff and drift.

In the development of new and improved pest control methods, whether they be chemical or otherwise, research should be directed toward learning as much as possible about the potential of the new method including its efficiency in maintaining pest populations at the lowest economic level as well as its compatibility with other chemical and nonchemical control methods.

There is also need for more research on pesticide residues (especially herbicides and insecticides) as they affect plant species other than the crop intended.

An additional area needing attention is research into the methods for disposal of pesticide wastes and empty pesticide containers. An incinerator capable of rendering these materials harmless and which can be built at a reasonable cost would be a useful tool in eliminating environmental contamination in manufacturing and formulating plants. Methods for cleaning up application equipment and disposal of contaminated water, containers, and surplus pesticides at the user level also are needed. Information developed might be incorporated into directions for disposal on product labels.

RADIOACTIVE SUBSTANCES

The Problem

Agriculture is primarily a receptor rather than a donor of radioactive pollutants. The major threat to agriculture appears to exist in the form of nuclear fallout because of war or aggression. The most likely threat will be in local situations where accidental release of the byproducts of earthbound use for peaceful purposes brings plant and animal life into contact with radionuclides.

A large number (200) of isotopes are present in nuclear fallout, the more biologically important of which are the strontium, barium, cesium and iodine. There is presently little danger from these elements because of their low level and the capacity of the soil to absorb and tightly hold them to a concentration far above that which currently exists. To this extent some interest is expressed in researching soils as a pollutant-absorbing technique.

State of the Art for Dealing with Radioactive Substances

Unless wide-scale testing programs are reinstated, the danger of nuclear explosions as a source of radioactive damage in agriculture will likely continue to diminish. Such former explosions, however, have placed heretofore unknown radioactive substances such as Sr-90 and Cs-137 into the environment. Even in clean weapons, there are releases of other substances, such as tritium, for which the effect on biological life is neither known nor shown to be harmful. In the event of nuclear war, or accidental release from peaceful use, time to conduct research will be severely limited, if available at all. A knowledge of the potential effects of radiation is required to determine needed courses of action. In both cases, the real danger will most likely result from exposure to or ingestion of long half-life radionuclides.

The exact magnitude of this pollution is, therefore, hard to gage because no evidence supports any real danger at the moment. Increased use of nuclear reactors, evidence of radioactive concentration through collections such as sedimentation in salt water estuaries and the possibility of irreparable harm of their sterilizing effects on seed material and the seemingly irreversible condition of uncontrolled tissue growth or destruction -- these consequences demand a continued awareness of the dangers of unpreparedness.

Biological damage is a subject of continuing concern. Agencies such as the Atomic Energy Commission and the Public Health Service are involved with gathering knowledge about handling, storing and disposing of radioactive wastes and on safe exposure periods and decontamination techniques. Much of this knowledge would appear to be directly transposable to the problems concerning agriculture. Agriculture does use radioactive substances but in controlled research where any danger is likely highly localized. Use of radioactive treatments for food sterilization and preservation comes under close regulation by FDA; thus pollution from these sources is not imminent or troublesome. Consequently, present effort does not suggest urgency for great expansion of researching radioactive substances as a pollutant to or from agriculture; but because of the irrevocable nature it would appear both feasible and essential to support some activity so as to assure a continuing state of preparedness in the event of a nuclear emergency.

Research Needs

** Level of Effort **

Estimated Current - 0 SMY

Recommended FY 1977 - 10 SMY

1. The collecting, economic programming, and organizing of alternatives in the event of a nuclear emergency, such as protection from contamination, decontamination, and the reinstating of plant and animal life. These analyses must be made on a synthetic basis; i.e., by modeling techniques, in order for the information to be available before the fact; after the fact will be too late.

   Specifically, the feasibility and needs for minimal protection of crops and livestock justifies further attention. Economic alternatives to be studied here are the cost of food storage to supply a contaminated area vs decontamination or evacuation. 1977 SMY 1

2. A program of assaying effects of known or most likely residues from industrial-commercial usage of radionuclides and civil works nuclear explosives on the long-term physiology of important plant and animal life. 1977 SMY 2

3. The development of plant and animal forms which have long-term genetic immunity to radioactivity and/or the ability to reject radionuclides. 1977 SMY 3

4. A continuing effort to evaluate the degree of exposure to radioactivity as related to the permissible use of a substance, such as food, livestock feed and seed.

   The total recommended research effort for the four cited research areas is 8 scientist-man-years. It is recommended that the projected research effort in terms of scientist-man-years reach the indicated level by 1972 and be continued to the year 1977 at these levels. 1977 SMY 2

5. Attendant to all aspects of research on radioactive pollutants are some key economic questions. There are three major alternatives to be studied here - the cost of (a) food storage to supply a contaminated area vs (b) decontamination or (c) evacuation of the area. These analyses need to be made on a synthetic basis; i.e., by use of sophisticated modeling techniques, in order for the information to be available before the fact. 1977 SMY 2

AIRBORNE CHEMICALS AND PARTICULATES

Airborne Chemicals

The Problem

The major airborne chemical contaminants are sulfur dioxide, fluoride, carbon monoxide, ozone, nitrogen oxides, peroxyacetyl nitrate, and various hydrocarbons such as ethylene. Of less or more localized importance are chlorine, hydrochloric and sulfuric acid, ammonia, and carbon bisulphide. About 129 million tons of chemical contaminants are emitted into our atmosphere annually by exhaust from internal combustion engines, industrial mills, smelters, chemical manufacturers, petroleum refineries, power plants, refuse burning, home heating, forest fires, and agricultural burning.

Vegetation is subjected to chronic injury in and near every metropolitan area. In southern California, acute injury to vegetation is widespread. At least 14,000 square miles of vegetation in that State are afflicted with airborne toxicants, and the entire Central Valley of California is threatened by air pollution. Losses in the State have been estimated at $132 million annually. Injury from photochemical air pollution has been reported from at least 27 States and probably occurs, to some degree, in all States. Nationwide losses to agriculture and forestry due to noxious chemicals in the atmosphere are estimated at $500 million or more annually.

Agricultural endeavor makes a local contribution to chemical air pollution in the form of hydrocarbons and smoke emitted from burning crop residues in fields. Fires in our forest produce upwards of 500 thousand tons of hydrocarbons annually.

The concentration and dispersion of air pollutants from the various sources are determined by topography and meteorological conditions. Pollutants accumulate near the ground during periods of atmospheric stagnation. Inversions occur which effectively suppress vertical dissemination and lead to severe pollution problems in industrial or metropolitan areas, as Los Angeles and New York. Under such conditions, potentially lethal layers of toxicants may be entrapped for days. Considerable fluctuation in levels normally exist during the day. Peak levels of an hour or two duration have more significance than daily averages, especially when relating to acute vegetation injury.

Different air contaminants have specific effects on agricultural crops and forest trees.

Sulfur dioxide. One example of the drastic effects of sulfur dioxide contamination still prevails at Copper Basin around Ducktown, Tennessee. Over a century ago, this basin was covered with hardwoods and some conifers. Open-hearth furnaces installed at mine locations were most active in the years 1890-1895. Soon after 1900, the sulfur dioxide fumes had killed most of the vegetation in the basin. Even today, some 7,000 acres to the leeward of the smelters are devoid of vegetation. Erosion has been intense. Another 17,000 acres surrounding the nude area are devoid of trees and produce only broomsedge and some plantings of kudzu. White pines 30 miles from the smelters were injured. An estimated 25 million tons of sulfur oxides are emitted into the atmosphere over the United States every year, primarily from the use of fossil fuels.

Injury to vegetation depends on the concentration in the atmosphere, length of exposure, wind speed, and other aerometric factors, as well as the tolerance of the species. Alfalfa, wheat, and conifers are relatively sensitive to SO_2, whereas potatoes, corn, and maples are more tolerant. If the SO_2 content of air is 0.3-0.5 parts per million for several days, sensitive vegetation will be injured. The threshold value for alfalfa is about a one-hour exposure to 1.25 ppm of SO_2. Since industry and metropolitan areas in the United States are pouring 25 million tons of sulfur oxides into the atmosphere each year and the concentration is much greater in some areas than others, appreciable SO_2 injury is found and can be expected to increase on forest trees, horticultural, and field crops.

Fluorides. Airborne fluorides have been a serious toxicant to vegetation and indirectly to animals. The industries mainly responsible are aluminum reduction, smelting of iron and nonferrous metals, ceramics, and phosphate rock processing. Manufacturers have made progress over the last decade in installing equipment to curb fluoride effluent, yet the problem continues because not all fluorides can be removed. Fluorides act as cumulative poisons. In 6 days, corn foliage can concentrate from 5 ppb of atmospheric hydrogen fluoride to 178 ppm on a dry weight basis. Gladiolus, Italian prunes, peaches, and grapes are sensitive to low levels of HF. In areas with atmospheric HF averaging 0.5 ppb, some species accumulate up to 500 ppm on a dry weight basis during a growing season. Fluoride injury on Ponderosa pines has been detected 20 miles from an aluminum smelting plant.

Chronic fluorosis may develop in livestock from ingestion of small amounts of fluoride over several months or years. Feed containing contaminated forage grown near industrial areas emitting fluorides will induce fluorosis. If animals receive a mineral mixture of water containing fluoride, the effect of the contaminated forage will be accentuated. Cattle are most sensitive to fluorides, followed by sheep, swine, horses, and poultry. Cattle may ingest about 1 milligram of fluorine per kilogram of body weight per day without harmful effects if they are in good health.

Symptoms of fluorosis are excessive erosion of the teeth, staining, pitting of the enamel, and exposure of the dentine. In severe cases, joints may become enlarged, and increased bone density may become significant.

Peroxyacyl nitrates (PAN's) and ozone. Based on current information, peroxyacetyl nitrate (PAN) and ozone are the primary toxicants in photochemical smog. Compounds closely related to PAN exist and are known collectively as peroxyacyl nitrates (PAN's). There are many sources of compounds that will react in the presence of sunlight to produce PAN and ozone, but automobile exhaust is the major contributor (Table 2).

PAN is extremely toxic to citrus, forage, salad crops, ornamentals, and coniferous trees. Acute leaf damage from PAN on sensitive species has been observed following a few hours' exposure to 0.03 ppm in ambient air. PAN produces injury symptoms on the lower surface of leaves, whereas ozone primarily injures the upper surface. PAN also retards growth and stimulates leaf abscission. Crops of romaine lettuce have been completely destroyed. Cigar-wrapper tobacco leaves beneath cloth shade in the Connecticut Valley and Florida, have been seriously damaged by "weather fleck", due primarily to ozone. Sensitive plant species, such as tobacco, alfalfa, and white pine, may be damaged after exposure to 0.06 ppm ozone for about four hours. Damage due to PAN and/or ozone has been observed in 27 States and the District of Columbia. Because levels are higher, ozone is probably more destructive than PAN to vegetation.

Oxides of nitrogen. Nitrogen oxides are produced by high temperature combustion and may be emitted by any fuel combustion source. Nitrogen dioxide causes irregular blotches of collapsed tissue near the edge of the leaves. Pinto beans and tomatoes have shown reduced growth and leaf distortion when exposed to 0.5 ppm of nitrogen dioxide for 10 to 22 days. Most of the time, concentrations of nitrogen dioxide in the atmosphere near sources of effluent are below 0.3 ppm.

Ethylene. Cotton plants growing downwind from industrial establishments making polyethylene were found to be seriously damaged by ethylene contaminated air. Air samples revealed 0.04-3 ppm ethylene. The injury was identical with that artifically induced by 3 ppm of ethylene in the laboratory. Ethylene in the atmosphere, attributed primarily to emissions in auto exhaust, has caused considerable loss to orchid growers, especially in southern California and near other large urban centers. Exposure for six hours at 0.05 ppm will cause sepal damage to Cattleya orchids. Carnation flowers often fail to open after a six-hour exposure to 0.1 ppm ethylene.

Lead compounds. In the middle twenties, tetra-ethyl lead began to be added to gasoline, enabling use of engines with higher compression and higher efficiency in energy conversion. Since that time, millions of pounds of lead have been poured into the atmosphere from motor vehicle exhausts. Eventually, most of this is deposited on soils and plants.

TABLE 2. National Sources of Major Air Pollutants - 1966

Source	Pollutant						
	Carbon Monoxide	Sulphur oxides	Hydro-carbons	Nitrogen oxides	Particu-late matter	Misc. other	Total
	(millions of tons per year)						
Motor Vehicles	66	1	12	6	1	<1	86
Industry	2	9	4	2	6	2	25
Generation of Electricity	1	12	<1	3	3	<1	20
Space Heating	2	3	1	1	1	<1	8
Refuse Disposal	1	<1	1	<1	1	<1	4
TOTAL	72	25	18	12	12	4	143

Source of data: Public Health Service

In Los Angeles, the average air concentration is 2.5 micrograms of lead per cubic meter of air.

Pasture grasses collected at the intersection of two U.S. highways near Denver contained 3,000 ppm lead, while grasses collected next to a less-traveled roadway contained 700 ppm. Grasses collected 50 to 100 feet away from the latter road contained 5 to 50 ppm of lead. The lead content of forage is a potential hazard to the health of livestock.

Summary

Judging from past trends, economic losses due to the effects of air pollutants on agriculture and forests are likely to become worse. Recently, evidence of a synergistic (more than additive) action of low concentrations of ozone and sulfur dioxide was obtained. The mixed gases caused plant injury, whereas the same concentration of individual gases caused no injury. As several toxicants are usually present in polluted air, we must be concerned about the additive effect of the various toxicants on vegetation.

There is increasing evidence also to show that the greatest loss to vegetation from chemical air pollutants is from chronic rather than acute injury; for example, the continued exposure of citrus to toxicants in photochemical smog reduced growth of the trees and yields of fruit, although acute injury was absent.

As these noxious chemicals continue to pour into the atmosphere, and as capability in diagnosing damage to plants and animals increases, estimates of annual damages by air pollutants to vegetation and livestock can be expected to soar. Global production of organic volatiles from vegetation are estimated between 200 and 400 million tons annually. Approximately one-fourth are terpenes from coniferous sources. Their role in photochemical air pollution is poorly understood.

State of the Art for Dealing with the Problem of Airborne Chemicals

The amount of research effort has increased to ascertain the effects of air pollutants on vegetation. The extent of effort varies according to pollutant. Very little research is underway to evaluate effects of combinations of pollutants.

Sulfur dioxide. There has been almost no research on the effects of sulfur dioxide on vegetation conducted in the United States for about 30 years. Just prior to that time, there were many studies on vegetation because of damage near smelters. Most of the recent information on effects of sulfur dioxide is from studies in West Germany. Information from this source on

the effects of intermittent exposure and fluctuating concentrations of the gas is especially significant. There is need for more information on response of presently grown varieties of crop plants to sulfur dioxide. Better data is needed also to establish air quality standards. The recent discovery at Beltsville that sulfur dioxide and ozone mixtures at ambient levels in air act synergistically to injure plants has stimulated interest and established further needs for research with these toxicants.

Fluorides. The relation of fluorides in forage to animal maladies is generally well-known. Studies have continued primarily to determine the nature of action of fluorides on vegetation. Some plants accumulate several hundred parts per million fluorides without injury, whereas others show injury when levels reach about 100 parts per million. These levels may accumulate with only 1 part per billion or less fluoride in air. Studies should be continued to determine the effects of low concentration of fluorides on crop production and to elucidate the nature of action.

Peroxyacyl nitrates (PAN's) and ozone. The biochemical and physiological nature of injury to vegetation by peroxyacetyl nitrate (PAN) the principal constituent of PAN's, and ozone have been the subject of many investigations in the past decade. It was established that plants must have light immediately before, during, and after fumigation with PAN if injury is to occur. Little is known about levels or effects of PAN in the Eastern United States. Pinto bean has been the subject of most investigations with PAN. Many ozone studies have been with tobacco. More research is needed to determine the threshold of injury for many species, and the possibility of interactions with other pollutants, such as established for sulfur dioxide and ozone.

Oxides of nitrogen. The evidence is of recent origin that 0.5 parts per million of nitrogen dioxide for several days causes discoloration and reduced growth of some plants. These results stimulated new interest in this pollutant as a plant toxicant. It is well-known that nitrogen dioxide is a participant in the formation of the photochemical oxidant ozone. The level of nitrogen oxides is increasing in air. More research is needed to determine the extent of injury and nature of action by this pollutant. The possibility of interacting effects with other pollutants demands investigation.

Ethylene. It is well-known that orchids and some other ornamentals are seriously affected by ethylene. No doubt, many species of plants are affected to a varying degree. The toxicant is much more difficult to remove from air introduced into greenhouses than ozone and most other pollutants. More research is needed on the effects of ambient levels of ethylene now found in urban areas.

Lead. Although there are many research reports concerned with lead from auto exhaust in urban areas, there are few that refer to this pollutant on vegetation in urban or rural areas. It is known that vegetation near major highways is contaminated. Plant species vary in their normal lead content,

and there is little information on the relation of plant uptake of lead from soil or fertilizers which are applied. The entire dietary intake of lead for animal and man needs review and further study.

Airborne Particulates

The Problem

(Agricultural Sources)

Annually, an estimated 30 million tons of natural dusts enter the atmosphere. Most arises from fields under cultivation, deteriorated range lands, and sand dune areas. Application of pesticides and the agricultural industries, such as cotton ginning, alfalfa milling, harvesting operations, feed grinding, and feedlots generate particulates of various kinds and amounts. The bulk of these dusts is either removed or settles nearby, but the small particles travel long distances and are injurious to health and welfare. Particulates in the internal atmospheres of feed mills and farm buildings, as those used for livestock production, offer special types of problems affecting health and equipment. Large amounts of residues from agricultural and forestry operations are burned as a means of disposal and generate millions of tons of particulates in smoke.

(Sources other than Agriculture)

Particulates as measured by dust fall in cities may amount to 50 to 100 tons per square mile monthly. The amount and distribution of the particulates are a reflection of population density and the nature of industrial operations. Approximately 12 million tons are emitted annually. Fuel combustion is a primary source. The smelting of ores, strip mining, pulp mills, fertilizer and cement plants, construction and foundry operations, incinerators, and road construction are additional sources of particulates.

Effects of particulates. Natural dusts coat the foliage of nearby crops, ornamentals, and trees, impairing growth and quality of the product. Leafy vegetables, small fruits, and ornamentals are especially damaged by dusts. Dusts contribute to respiratory ailments of man and animals, affect highway and air vision, damage machinery, and permeate buildings. Pesticides may be carried long distances on natural dusts and could cause crop damage miles from the area of application or be carried to farm ponds and tributary streams used for recreation. Odors are carried by particulate matter as dusts from feedlots, feed processing, and milling industries. Airborne dusts from agricultural endeavor are, therefore, of serious concern due to the illness and irritation, as well as to the filth and depredation to

locations and equipment. Fluorides may be present in the atmosphere in solid as well as gaseous forms. Both forms may be accumulated by vegetation, causing injury to the plant and/or serious losses to cattle which eat the foliage.

State of the Art for Dealing with the Problem of Airborne Particulates

Due to research and programs of action agencies such as the Soil Conservation Service and the Federal Extension Service, the blowing of dust has been greatly reduced in recent years. With increased demands for food and farming of marginal lands, especially during dry years, the problem of airborne natural dust could become even more serious than in the 30's. There is little doubt that certain dusts naturally deposited adversely affect vegetation, especially near urban centers, industrial plants, and power stations. Particulate fluorides deposited on leaves are less injurious than gaseous flouride because of greater difficulty in penetrating the leaf. The effects of more inert dusts are not as well-known. Most information seems to be available on cement dusts. Fly ash deposits tend to raise pH and add minerals. The amount of boron added to soil near some large power stations could reach toxic levels. Plant growth may be reduced because the dust deposits reduce light available for photosynthesis.

The effects of dust on market value of vegetables and ornamentals is evident, but there is little information on the extent and magnitude of loss. More research is needed to relate particulate emissions and composition from some industries to plant response including effects of particle size, deposition rate, and interactions of particle size and composition.

Airborne Chemicals and Particulates

Research Needs

(All Airborne Chemicals and Particulates)

** Level of Effort **

Estimated Current - 41 SMY

Recommended FY 1977- 114 SMY

(Airborne Chemicals)

** Level of Effort **

Estimated Current - 18 SMY

Recommended FY 1977 - 75 SMY

Insufficient basic knowledge hampers full development of control measures, but there are many ways of reducing the effects of air pollution by application of present knowledge and use of available methods and procedures. For example, procedures are available to determine, to a considerable extent, the sensitivity of plant species to specific pollutants and to a more limited extent for combinations of pollutants. There are thousands of important plant species for which there is no information relative to single pollutants, and there is essentially no information on sensitivity of any plant species to combinations of pollutants. Yet, it is known that combinations of ozone and sulfur dioxide produce synergistic (more than additive) effect on certain tobacco varieties which were tested. Increased attention must be given to the effects of combinations of pollutants.

Research is needed to:

1. Determine sensitivity of hundreds of species of plants and farm animals to specific pollutants and combinations of pollutants. Such information is beneficial to agriculture to make best choices and to establish air quality standards for agriculture and forestry. <u>1977 SMY 12</u>

2. Develop tolerant varieties of plant species such as used for production of food and fiber, and for shade, ornamental, and roadside plantings, especially near urban centers. <u>1977 SMY 14</u>

3. Assess the biochemical, physiological, pathological, and economic effect of pollutants, singularly and in combinations and to determine the nature of resistance of pollutants. The possibility of quantitative and/or qualitative difference in amino acids and enzymes is being explored to a limited extent. Resistance, in certain onions, is based on a single dominant genetic factor. If the nature of resistance of other species to specific pollutants were known, development of resistant varieties and other control measures could be accelerated. <u>1977 SMY 11</u>

4. Assess the extent of damage by pollutants, particularly chronic damage. In some areas, waste levels in air are near the maximum tolerable concentration with respect to other uses. Much information could be obtained by comparing growth of plants and animals in carbon-filtered versus ambient air at more locations in the country. Research is needed to develop other methods which will give input as to the economic loss, such as assessing damage by air pollutants by remote sensing techniques. 1977 SMY 10

5. Develop improved facilities to evaluate effects of long-time exposure to low concentrations of pollutants. Better and somewhat different facilities are required for such studies than needed to determine the effects of a few hours' exposure to relatively high concentrations. Long-term exposures are needed to measure effects of pollutants on plant growth and reproduction. 1977 SMY 6

6. Evaluate the cleansing action of crop and forest species to particulate and gaseous pollutants, taking into account environmental factors, such as effects of wind-speed on absorption of pollutants by leaves. 1977 SMY 6

7. Develop improved chemical and engineering procedures for pollution control in greenhouses and on the assessment of plant injury, giving attention to new greenhouse designs which will compete with the industries for urban land. For example, development of filters to remove specific pollutants, such as ethylene, would be useful in evaluating the effects of low levels of this pollutant in urban atmosphere on vegetation. 1977 SMY 6

8. Monitor levels of pollutants and frequency of air pollution episodes in nonurban areas. There is practically no information on background pollution in strictly agricultural areas. Some evidence is available, however, that phytotoxic levels of oxidants, especially ozone, exist tens and even hundreds of miles from urban centers. 1977 SMY 4

9. Identify the reducedtoxic materials and undesirable odors in the internal atmosphere of buildings used for livestock and poultry production. Knowledge in this area is needed because of effects to animals and human health, and the need to reduce odors from farm operations. 1977 SMY 4

10. Better describe the symptoms of pollution injury, such as improved and more available colored photographs showing macroscopic and microscopic characteristics of plant injury. 1977 SMY 2

(Airborne Particulates)

** Level of Effort **

Estimated Current - 23 SMY

Recommended FY 1977 - 37 SMY

1. Reduction of airborne natural dusts depend primarily on the control of soil blowing. Although information is available from past research on many of the processes involved, more research is needed to obtain even better methods of control. Such research should include basic studies on wind erosion, modification of tillage practices, machines to provide lasting crop residues and soil aggregation to resist soil detachment, use of chemicals and petroleum soil stabilants, tolerance of plants to wind-blown particles, better varieties of grasses and crops to tie down soils, and a better determination of the interrelations of the many factors involved.

   Additional studies are needed to evaluate the amount and nature of reduced radiation of light attributable to airborne particulates to provide a profile of particulates on plants, improve harvesting equipment, reduce dust release in air streams, and evaluate improved grinding mechanisms such as shearing or crushing vs grinding. 1977 SMY 12

2. Windbreaks are known to reduce soil erosion, affect crop production, conserve soil moisture, afford protection to livestock, and beautify homesteads. To better fulfill the many needs of protective belts of trees and other vegetation and secure the best adapted grass for arid regions, there should be expanded research on selection and development of the most suitable species. Research is also needed on cultural practices which best maintain vigor, density, and longevity of plantings. 1977 SMY 6

3. Dusts from cotton gins, feed mills, alfalfa mills, feedlots, etc., should be captured. More research is needed to reduce especially the microscopic particles. Especially recommended are more effective filters and improved cyclones that clean air in connection with these facilities. Better techniques are needed to collect materials such as gin trash and products from harvesting, to rid residues of plant pests, and to facilitate the return of these residues to soil as beneficial organic matter. <u>1977 SMY 7</u>

4. Methods of removing waste agricultural and forestry products by methods other than burning should be developed, such as accelerated rates of decay by appropriate sprays or by modifying crop culture or harvesting methods. If burning is necessary, conditions which result in the most efficient and complete burning should be carefully determined, taking into account meteorological factors. <u>1977 SMY 4</u>

5. Soil mapping. Changes in soil as a result of intense air pollution, as from large coal-burning electric generating plants, from heavy industrial areas, and from auto exhaust should be analytically established. Special attention must be given to heavy metals in the fly ash and other exhaust settling on the ground. <u>1977 SMY 2</u>

6. Research is needed to reduce particulate pollution in the internal atmosphere of such agriculture buildings as feed mills and those used in livestock production. <u>1977 SMY 4</u>

7. Although some information is known about effects of cement dusts, there is relatively little information on the effects of other particulates, as natural dusts and components of fly ash on vegetation. Although the sand-blasting effects may be obvious on vegetation, there is little specific information as to reduction on photosynthesis and plant growth caused by particulate pollution. <u>1977 SMY 2</u>

(General)

** Level of Effort **

Estimated Current - 0 SMY

Recommended FY 1977 - 2 SMY

1. Methods of least cost for controlling airborne chemicals and particulates need to be determined. Where there are opportunities for increasing the efficiency of the production and processing of agricultural and forestry products, the reduction of these costs should be calculated in order to determine if industry can afford to assume all or a portion of the costs of control. 1977 SMY 2

NOISE

The Problem

In a recent popular press it was reported that man is born with fear of two things: sudden noise and falling. The place of noise as a pollutant is perhaps best summarized in the Conservation Foundation Letter for December 29, 1967. It reports on the growing concern by Secretary Udall and the organization of teams of scientists to study the problems of noise (sonic booms). Most of the following is an abstracting of material reported in this Conservation Foundation Letter.

Approximately thirty years ago the American Medical Association put us on notice that "the multiple and insidious ill effects of noise constitutes an inadequately recognized, baneful influence on lives of millions of persons throughout the country." Dr. Vern Knudsen, former chancellor of the University of California at Los Angeles, reports that noise "is one of the chief drawbacks to the enjoyment of modern urban living."

Acoustic experts believe that the noise levels will grow not only in urban centers, but with the increasing population proliferation of machines, invade the countryside now occupied by agriculture. There are a few documents indicating that many of our domesticated livestock are, in fact, affected by noise. It is not uncommon to see reports that the use of radios places a noise level which aids in avoiding panic by sudden disturbances. There is also testimony of panic and subsequent death of poultry caused by sudden sound. Some reports indicate that animals will grow faster or produce better when exposed to low levels of soothing or suggestive sounds.

Noise has been defined as "unwanted sound." The lowest sound detected by a keen human ear is called a decibel (db). The decibel scale is logarithmic, the actual sound pressure on the ear increasing by the power of ten times with each ten decibel increase. Consequently, when the level goes up from a normal conversational 50 decibels to 100 decibels, the ear suffers not just a double of pressure but a 100,000 fold increase. Many animals have ears which are far more sensitive than those of a human, both in terms of level and frequency. Consequently, it is logical to suspect that noise would cause varying levels of disruptive behavior. Already there is some research which indicates abnormal sound can result in physiological malformities in poultry. Also some clinical evidence suggests that noise may reduce animal fertility.

Because it is the sudden difference in level of intensity which causes startling effects, steady low levels of sound, called ambient noise, mask the difference in intensity thus diminishing the effect.

The effects of noise fall into four general categories: annoyance, disruption of activity, loss of hearing, and physical and mental deterioration.

State of the Art for Dealing with Noise

There is considerable effort to evaluate and control noise as it affects humans, particularly with respect to work performance and fatigue. Recently serious attention has been given to designs of agricultural machinery which will reduce noise.

There seems to be no coordinated effort in which noise is specifically being related by research to loss or change in production of livestock. It appears that this will become a pollutant of increasing importance.

Research Needs

** Level of Effort **

Estimated Current - 1 SMY

Recommended FY 1977 - 7 SMY

1. Research to associate the reaction of the various domestic livestock with present scales for measuring sound. 1977 SMY 1

2. Studies to investigate the effect of the various levels of noise on the productivity of domestic livestock. 1977 SMY 2

3. Investigations of ways to filter, alter, or absorb excess levels of sound. 1977 SMY 3

4. Economic evaluation related not only to abatement of noise for production purposes but also in regard to design of agricultural equipment which otherwise would add unnecessarily to the noise level. 1977 SMY 1

HEAT

The Problem

Heat is a pollutant by virtue of causing unsatisfactory temperature or reducing oxygen content of water. Introduction of significant quantities of heat into surface water bodies produces the same general effect as added oxygen-demanding wastes.

Agriculture, including agri-business and forestry, may be both receptor and contributor, although from the most critical aspect the receptor role is most pertinent. Agricultural and forestry products processing plants do undoubtedly discharge water somewhat warmer than that withdrawn, but this is not of widespread significance. Timber cutting along streams will result in increased water temperatures of three to four degrees if all shade is removed. Burning of the slash following timber cutting will be followed by a significant increase in soil surface temperature. Where water is impounded in shallow bodies, such as farm ponds, a temperature rise follows. Water withdrawn from ground-water sources is heated when used for irrigation.

None of these heat sources produces a concentration of this pollutant to the problem-producing extent that industrial plants do with water that has been used for cooling purposes. Water temperature below heavy industrialized areas is frequently high enough to cause heavy fish kill, or it may block migration of anadromous fish, or loss of desirable game fish followed by a buildup of trash fish. Although this is largely a point source, there are so many sources that the problem has some national significance.

The slowing down of biological activity by absence of conducive temperatures has caused problems in the management of biological wastes.

In general, where heat has built up to significant pollution levels, it is the result of not foreseeing the levels of industrial buildup and providing control of heat output, rather than absence of know-how.

State of the Art for Dealing with Heat as a Pollutant

Fisheries biologists in the U.S. Department of the Interior, State research institutions, universities, etc., have developed fairly good knowledge of environmental characteristics, including heat levels, required by most of our most important game fish.

Agricultural and forestry scientists have developed much information as to limiting and optimizing levels of heat on growth and well-being of plant life.

Considerable effort has been expended and is continuing on finding limits of heat stress on animals.

Research in other physical sciences as well will be applicable in the event of local need. For example, research basic to development of more effective heating and cooling systems will give leads as to ways of dissipating heat without impairing the environment.

Although some of the foregoing may not be directed at heat as a pollutant, the knowledge gained is directly applicable to solving problems associated with heat pollution.

Research Needs

** No Additional SMY's Are Recom-

mended for this Area by FY 1977 **

We do not see heat as a pressing pollution problem requiring major research effort by agriculture. We have concluded there is no need to generate a new research activity of any appreciable scale. Some economic study of alternates at the local level will be needed. The costs of modifying the environment to reduce the effect of temperature need to be estimated in order to establish cost-benefit ratios. Such information must be widely disseminated to inform the public of the possible choices in financing such heat-producing activities as power plants, nuclear and conventional.

SOCIOECONOMICS

The Problem

The United States population is currently increasing at about two percent per year. At this rate of increase, the present population will be doubled in one generation. The challenge for agriculture, implicit in these figures, is not limited to producing and distributing more and better food for more people. It includes the problem of their living space. A great deal of low-use space remains, of course, but no informed person can believe that twice or four times as many people can be permanently accommodated in it without serious strain on all environmental resources. Agricultural science, in all its aspects but perhaps especially because of its socioeconomic insights, shares in the national responsibility to plan wisely for the future that is so plainly in sight.

The "megalopolitan mentality" characteristic of many planners has recently been challenged by Secretary Freeman. Of the several myths on which he finds it to be based, the most transparent is the false assumption that Americans want to live in cities. What the great majority of Americans want is to live in the country; suburban living is what they accept as the best available compromise between rural amenities and urban necessities.

Suburbanization confronts agricultural science with a host of problems. These problems are rapidly becoming more acute, because as the total population increases, advancing technology encourages a disproportionate increase in suburbanization. "Environmental quality" is simply another name for most of the problems. In noting that the "extended town-country community" is a viable alternative to megalopolis, therefore, Secretary Freeman articulated a national goal, to which all research on environmental quality must be directed. The benefits of environmental quality must be paid for; the question for the economist is "Who pays how much for what?" Beyond this researchable objective, of course, lies a series of public policy decisions about who should pay. These decisions are not for economists, or any scientists, to make, but they cannot be made fairly without adequate and sensitive economic analysis. To date, economic interest has centered about the classical concept of the "market place" in dealing with the problems of production and marketing. Environmental quality, however, is not a classical problem, and raises technical questions that no one has yet answered satisfactorily. One reason is that quality is a resource which in the past has been considered a "free good." Resource economics, like "welfare economics," is a field in which this classical concept is misleading.

To illustrate, when fumes from a smelter damage a crop, the injured farmer can demand damages, or sell his farm and move away. But the damage caused by the continued pollution is not limited to the farmer's injury, or even to agriculture as a generalized institution. It is diffused throughout society in ways that have not even been noticed until very recently since most of the costs and benefits are not coordinated by any ordinary market mechanism. Suburbanization, when it forces sale of agricultural land for other purposes, is a process of the same kind as pollution, but vastly more complex in its effects, and methods of analyzing its costs and benefits are not yet available. Until they are, nothing approaching a national zoning policy for agriculture can be contemplated.

State of the Art for Dealing with Socioeconomic Aspects of Pollution

Much economic research on environmental quality is already being conducted. Projects that pollute air, water, or soil, and compensatory projects that deflect or abate pollution, can be handled on a project-by-project basis. The economists' standard measure, increased net income from which to pay the cost, serves reasonably well, provided one looks beyond the visible buyer-seller relationship and adopts some unorthodox and ingenious methods that permit estimation of all the costs and benefits.

Several kinds of pollutants, and the modes of economic research recommended for evaluating their costs are listed in this section. Substantially increased effort on pollution projects by agricultural economists and sociologists working together with other disciplines of agriculture is recommended, but the essential point about all these separable problems or projects is that the economic techniques for handling them are fairly well known.

When all the easily identifiable pollution problems are under control, however, agriculture's responsibility will not be discharged. Larger and less coherent problems that would remain include other components of population pressure or suburbanization, such as "pollution of landscape by people," or less picturesquely, the optimal balance between built-up urban areas and countryside. Quite new methods of analysis will have to be developed before these problems can be attacked or even well formulated on a national scale. These will require multidiscipline efforts. For example, social and behavioral scientists must evaluate costs and benefits of standards for quality of the soil and of the various patterns of use of land with respect to control and reduction of pollution and pollution damage. Physical and biological scientists and engineers must provide the technology required to meet and maintain such standards for soil and for land just as for air quality and water quality.

Research Needs

** Level of Effort **

Estimated Current - 2 SMY

Recommended FY 1977 - 32 SMY

This manpower projection is based on the assumption that the increase in SMY's in economic research on problems considered by other task forces will be forthcoming.

Beyond this effort explicitly directed at economic evaluation of pollution problems, research is needed on legal, political, and fiscal techniques that can be employed at local, State, and Federal levels to maintain an agricultural economy. Such research must include sophisticated socio-economic modeling.

It is essential to reserve for agriculture those lands best suited for it ecologically. To make this reservation effective and to distribute its costs fairly, some form of national zoning policy will be needed. Long before such a policy is adopted, however, much social and psychological information will be required. Without sociology, society's demands for clean air and water and for open space cannot be rationally assessed. Without psychology, the effects of declining environmental quality on mental health cannot be evaluated. Without a new political science greatly enriched by social psychology, the economist's assessments of major public policies cannot be communicated to the public. A sizeable number of additional SMY's will be needed for all this new social science effort. 1977 SMY 32

SYSTEMS ANALYSIS

The Problem

The designers of pollution abatement systems must often choose among a number of abatement procedures, select some point in the continuum of possible pollutant strengths at the discharge point of the system, and identify a particular part of the environment as the sink for the system discharge. Much of the research and analysis applied to these systems has dealt only with bits and pieces of the system. Lack of adequate data and the laboriousness of methods of analysis often severely limit the number of alternatives that could be compared and also prohibits a clear choice among a set of alternatives.

The broad scope of this problem was well stated by Dr. Mehren: "To insist on a clean environment is meaningless. How clean? At what cost? And for what purpose? The right amount of pollution must be planned with criteria set somewhere between the ideal of complete cleanliness and the havoc of uncontrolled filth. The right amount involves a calculated risk to society. It depends on where we are, what use we want to make of the environment and the quality of cleanliness for which we are prepared to pay.

"'The right amount of pollution' is perhaps a disturbing phrase. It does not mean that we--or anybody else--are going to plan to injure the environment in which we live. It does mean that we shall continue honestly and intensively to identify and analyze benefits and costs. We shall try to minimize hazard or offense; but we shall also try to maintain the living levels and the productivity and the strength of the American economy." 1/

Another facet of the problem is expressed by Biniek and Taylor, "When the general problem of waste management and environmental quality is viewed in total, it becomes obvious that solutions to one resource pollution problem may intensify other resource problems. With respect to waste disposal, we can burn it, bury it, sluice it away, let it blow away, or reuse it. Each of these alternatives may create problems or suggest opportunities. . . Transfers of pollution problems to other subject matter areas, or legal or bureaucratic jurisdictions are not solutions in any relevant sense." 2/

1/ See reference No. 9 on page 110.

2/ See reference No. 20 on page 111.

We need parallel sets of studies: (1) a thorough and careful appraisal of individual pollution situations, their sources, causes, pathway, ultimate destination, breakdown, and long range effects on man; (2) an appraisal of the synergistic effects of the total pollutional load. Some questions such as the following need answers: What diseases does this pollution cause? What further damage will it bring to my children and grandchildren? What additional costs accompany this pollution? Such questions should be answered in terms of the individual, the family, the community, the crops and beasts of the field, the birds of the air, the fish of the sea. Finally, we must ask: How can this pollution be reduced or eliminated? What will it cost? What institutional changes will facilitate its control?

State of the Art of Systems Analysis for Dealing with Pollution

The development of better data, together with the development of highspeed electronic computers, and the availability of newer analytical techniques have opened the way to more comprehensive analyses of relevant alternatives in the design of pollution abatement systems and the benefits which can be derived from the reduction or elimination of the pollution. Several professions are currently using techniques which are especially valuable where the system is so large as to defy analysis except with the aid of automatic data processing facilities, remote sensing, and data acquisition. For example, CPM (Critical Path Method), PERT (Program Evaluation and Review Technique), Monte Carlo methods, model sampling, simulation training devices, and gaining.

This approach (systems analysis) has been successfully developed in recent military-space projects. It need not be mysterious or ultra-sophisticated. The systems approach is organized common sense plus modern mathematical tools. It consists of defining, limiting, and analyzing problems; devising mathematical models; obtaining reliable data; investigating the results of alternative actions via the models; scheduling research and development . . . The systems approach requires a deep understanding of practical aspects of pollution. It requires learning by doing and allows adjustments as the program progresses. It can prevent crises and emotions from influencing decisions of a technical-economic nature.

One important limiting factor in development of systems analyses in pollution is the inadequacy of data describing the polluted environment. Systems of monitoring need to be designed and tested that will identify the kind and magnitude of pollution elements within the limits of accuracy required for the design of the abatement systems. The operation of the monitoring system is not considered to be a research function, but the design of the system is appropriate for research.

Research Needs

** Level of Effort **

Estimated Current - 2 SMY

Recommended FY 1977 - 6 SMY

Research should be limited to the development of models and their use. Input data needed for decision making with the models should be provided from the research indicated in other parts of this report. Facility needs are primarily a high capacity, high speed computer. Scientific competence should be readily available in computer technology, current analytic techniques and systems theory.

The newer techniques, frequently referred to as "systems analysis," require the joint efforts of many research disciplines for their most effective application. They are applicable for study of a subsystem such as animal waste management or for a much broader study to combine several pollutants and alternate methods of combining them, handling, treating, and making them "safe" in the environment. Development and use of the models required for these analyses will also reveal needs for additional research to refine the model.

Potential "pollution free" methods of producing the desired result should be considered as well as alternative methods for controlling the level of pollution by using present methods. Although the ideal of complete cleanliness should not generally be insisted upon, there may be situations where the complete prevention or control of one source may be the least cost way of reducing the level of another pollutant in the environment. Such a technique may permit a higher rate of discharge for another source for which there is either no available method of control or for which the available methods are relatively expensive.

Criteria and standards, if available, provide a sound basis for systems analysis studies. In their absence, however, alternative methods can be compared on a current state of the art basis.

The relative feasibility of accomplishing the desired result at reasonable cost should be ascertained at each step in the research, development, and demonstration process using whatever data are available. 1977 SMY 6

Ragweed as a Problem Benefitting from Systems Approach. One or more species of ragweed grow in every one of the 50 States--it infests most of the 300 million acres of pastureland in the Eastern United States and three of the 60 million acres of wheat stubble.

The ragweed problem entails present costs and benefits estimated to be as follows:

Costs:

1.	Forage loss on 300 million infested acres, 2.8 million tons corn equivalent feed units. Discount this loss by half for usual wastage in grazing	$0.50 billion
2.	Five million working days lost at minimum wage	0.50 billion
3.	Cost of desensitizations	0.10 billion
4.	Treatments of seven million acres new seeding with 2,4-D	0.02 billion
5.	Treatment of 30 million acres of pasture -- 2,4-D and mowing	0.09 billion
	Total cost	$0.96 billion

Solution:

Alternate I - Appropriate use of 2,4-D and 2,4-DB will kill ragweed. Cost of treatment of all infested acres with present technology-- $1 billion per year. An estimated three years would be required for eradication. Federal-State educational programs would be required under the leadership of Extension. Included would be repeated use of radio, television, newspaper, farm press. Agricultural Conservation Program payments for cost-sharing of treatment costs and Farmers Home Administration stipulation for control by borrowers should be included in the program.

Alternate II - Previous research has shown ragweed to be capable of eradication by appropriate treatment with 2,4-DB. This chemical is not harmful to legumes, but is more expensive than 2,4-D. It does damage tomatoes and some other useful plants.

Current research under Regional project NE-42, Weed Life Cycles as Related to Weed Control, includes the study of life cycle of the common ragweed (Ambrosia artemisiifolia). The ragweed phases of the project are supported by about $25,000 annually.

Research results show that ragweed has an unusual germination behavior that is not well understood and that its photoperiod response is very great.

Studies of specific sites where ragweed occurred naturally revealed some striking location effects. In noncropped areas, ragweed populations were frequently sharply delineated. Along highway shoulders populations often varied from very dense to none in a matter of one or two feet. In certain cases one side of a ditch had heavy populations, the opposite side none. In areas where excavations had been made, ragweed frequently was prevalent

on the "subsoil" but not on the adjacent undisturbed soil. In cropped areas it was noted that ragweed germinate readily in May and early June, but rarely does a seedling emerge after late June in spite of irrigation and cultivation. This is in contrast to purslane, white cockle, redroot pigweed, and lambsquarters.

Ragweed seed 18 months old germinates better than seed six months old. Under field condition, germination is very high in April and May and almost ceases by the first of June. In the laboratory alternating temperatures of 10° C for 16 hours and 30° C for eight hours gave the highest percentage germination. Germination was reduced more than 40 percent at a depth of 1 cm as compared to that on the surface.

Other suggested research approaches to ragweed control are:

a. Biological agents (pathogens, insects, virus)

b. Chemicals to prevent flower and seed formation

c. More potent and specific herbicides

d. Use of surfactants to enhance penetration and adsorption of 2,4-DB which would reduce the amount needed.

This research would be chargeable to RPA 209 and attention of Task Forces on cereal crops and on forage crops is solicited.

It is estimated that about eight percent of all people are allergic to ragweed pollen. Antigen is assumed to be the principal allergen.

Does Agriculture have research responsibility with respect to abatement of our pollution by the pollen? Does Agriculture have responsibility with respect to research on the ragweed allergen?

Here is a major problem in which economic costs are likely to remain large for some time. Research may find ways of reducing those costs. Realized social benefits would be substantial.

We feel there is a serious need to conduct a pilot study on the control of ragweed in a large contiguous area to determine the effectiveness of control procedures in reducing the allergenic potential in the area. <u>We do not have evidence to show that controlling large areas of ragweed would reduce the allergenic potential and health problems in an area</u>. We believe such information is essential to determine the practicality and value of large scale control and eradication programs and to determine research needs.

<u>Nitrogen as a Problem Benefitting from Systems Approach</u>. Use of Nitrogen (N) in corn fertilization in 1966, six million tons, was about 30 times that used in 1920, or a doubling time of about 10 years. Should this rate of

increase continue, use of fertilizer Nitrogen in the year 2000 would reach about 50 million tons, or about 300 pounds per harvested acre of cropland. This rate would only slightly exceed the current rate of cropland use in the Netherlands.

In crude terms, we will increase N from all sources by three times in order to double our harvest of N as useful protein. From the dollar standpoint this is good business. But, the standard fertilizer response curve is one of diminishing yield increments as fertilizer is increased. Data from the 1957 Yearbook of Agriculture might have been used to predict the yield of corn rather precisely. Doubling N at Prosser (40 to 80 lbs.) increased the yield 29 bushels.

Challenge: At 80 pounds N - 100 bushels of corn takes all you put in and that in the rain too - some runs off, some volatilizes. We are drawing on soil reserves.

At 300 pounds N - 150 bushels of corn, we put on twice the N we harvest, increased the N to be volatilized, run off, percolated or stored in the soil by 150 pounds per acre.

There are many areas; e.g., Texas High Plains, California Central Valley, Arizona Salt River, where recharge is a current pressing issue.

The three great sinks--land, sea, and air--receive and distribute the intermediate and end products of the biosphere. Plants metabolize carbon dioxide produced by animals, including man, and use sun's energy to produce and store starches, sugars, fiber, and wood. They release oxygen. Without plants, the oxygen in our atmosphere would disappear. Man would die or use vast amount of energy to reconstitute the air.

The nitrogen cycle also involves the three great sinks; it also includes plants, animals and microbes in cyclic synthesis of living substance and decomposition of dead substance. Man's use of increasing amounts of energy to convert atmospheric nitrogen to fertilizer nitrogen is his best assurance of enough food.

Concern has been expressed that high nitrogen fertilization of spinach and beets might lead to excess nitrates in baby food prepared from these vegetables. There is no evidence that nitrate content of these vegetables in U.S. groceries has increased during the past 60 years. It is true that there are wide variations in nitrate content.

SCIENTIFIC MANPOWER AND FACILITY REQUIREMENTS

MANPOWER

This report outlines the need for additional scientists by 1977, to man an expanded research effort in ENVIRONMENTAL QUALITY - Pollution in Relation to Agriculture and Forestry. It is assumed that these scientists should hold the Ph.D. degree or equivalent, and that they would come from a variety of basic and applied disciplines--chemistry, bacteriology, engineering, agronomy, entomology, economics, etc. They must be prepared to work together in interdisciplinary research teams to solve problems and also, in certain instances, to train students.

The current and projected manpower (SMY's) for research relevant to pollution in the USDA, SAES and Cooperating Forestry Schools are shown in Tables 2-4. These SMY data include all of the Long Range Study Research Problem Areas (RPA) 214 and 901 and portions of a number of others. Taken as a whole, they represent a projected "pollution research package."

Though an increasing percentage of American youth are entering and completing college, including advanced degrees, society demands scientific talent at a more rapid rate of increase; so there is increased competition among scientific missions for research talent. The research effort on pollution in relation to agriculture is and will be in that competition.

The problems are large and continuing; career scientists are needed. Opportunities for recognition and advancement are essential in order to attract scientists to pollution research.

It is recommended, therefore, that (1) undergraduate and graduate curricula in related professional areas--agriculture, engineering, biology, etc.--include sufficient subject matter in pollution problems that the graduate B.S., M.S., or Ph.D. will more likely be able to adapt his competence to this mission, and (2) that graduate curricula in universities with demonstrated competencies in fields related to this mission seek and receive sufficient financial support from State, private, and Federal funds to expand enrollment to help meet this need for scientific manpower. It is specifically recommended that USDA be provided authority and funds to finance graduate training grants for this purpose.

The Agricultural Research Planning Committee made allocations of SMY's for RPA's 214 and 901. These are shown in Table 3.

Table 3. Current and Projected Allocations of Scientist-Man Years to Two Research Problem Areas Dealing Specifically with Pollution.

Research Problem Area	SMY					
	1966			1977		
	SAES 1/	USDA	Total	SAES	USDA	Total
214 Protect plants and animals from air pollution	8	1	9	26	19	45
901 Alleviate soil, water and air pollution	67	45	112	216	194	410
Total	75	46	121	242	213	455

1/ Includes both State Agricultural Experiment Stations and Cooperating Forestry Schools.

The projected SMY increase of 275 percent for combined RPA's 214 and 901 is among the highest in the LRS. This Task Force considers these and other projected SMY's to be urgently and immediately needed.

Task Force projections for individual pollutants and subject areas within RPA's 214, 901, and others are summarized for FY's '72 and '77 in Table 4. More complete data, including estimates of levels of effort for FY 1966 are included in Table 5. Titles for RPA's identified in Table 5 are listed on page 108.

Table 4. SMY's Projected for Individual Pollutants and Subject Areas for RPA's 214, 901 and Others for FY's 1972 and 1977 as Components of a State Agricultural Experiment Station-USDA "Pollution Research Package."

POLLUTANT OR SUBJECT AREA	Task Force Projections in SMY's							
	RPA 214		RPA 901		Other RPA's		TOTAL 1/	
	SMY's							
	'72	'77	'72	'77	'72	'77	'72	'77
Animal & Domestic Wastes			60	98	25	42	85	140
Processing Wastes			62	93	14	40	76	133
Animal			(25)	(40)	(2)	(5)	(27)	(45)
Crop			(12)	(18)	(10)	(30)	(22)	(48)
Forest			(25)	(35)	(2)	(5)	(27)	(40)
Infectious Agents, Toxins and Allergens			20	26	213	244	233	270
Plant Residues			20	30	15	20	35	50
Sediment			20	38	147	216	167	254
Plant Nutrients			20	35	214	240	234	275
Mineral & Inorganic Substances			8	11	61	84	69	95
Pesticides			15	20	1733	1733	1748	1753
Radioactive Substances			3	6	4	4	7	10
Airborne Chemicals and Particulates	20	40	20	37	30	37	70	114
Noise	3	5				2	3	7
Socioeconomic Aspects			5	10	11	22	16	32
Systems Analysis			4	6			4	6
TOTAL	23	45	257	410	2467	2684	2747	3139

1/ Figures cited represent total SMY's. The totals for '72 and '77 cited in the lower right corner include estimated FY 1966 base figures of 2430 SMY as shown in Table 1. Details of estimated FY 1966 base values for individual pollutants and subject areas are shown in Table 5.

Table 5. Estimated Current and Projected State Agricultural Experiment Station and USDA Pollution and Pollution-Related Research: Scientist Man Year's (SMY's) for FY's 1966, 1972, and 1977.

RPA No. 2/	INDIVIDUAL POLLUTANTS OR SUBJECT AREAS 1/								
	ANIMAL & DOMESTIC WASTES	PROCESSING WASTES			INFECTIOUS AGENTS, TOXINS & ALLERGENS	PLANT RESIDUE	SEDIMENT	PLANT NUTRIENTS	MINERAL & INORGANIC SUBSTANCES
		Animal	Crop	Forest					
101									
102								15-20-25	5-8-11
103									26-36-46
104									
105						10-15-20			5-7-9
106									3-10-18
107							86-147-216		
108									
111								5-7-10	
201									
203									
204									
205									
206					16-18-20				
207									
208									
209					45-46-47				
210									
211									
212									
213									
214									
303									
304								50-52-55	
306								0-5-5	
307								90-93-95	
309								0-2-5	
313	12-25-42								
315								30-35-45	
401				0-2-5					
403			0-5-15						
406			0-5-15						
410		0-2-5							
701									
702					60-80-100				
706					50-51-52				
707					16-18-25				
901	15-60-98	15-25-40	5-12-18	10-25-35	10-20-26	10-20-30	10-20-38	10-20-35	5-8-11
908									
TOTAL	27-85-140	15-27-45	5-22-48	10-27-40	197-233-270	20-35-50	96-167-254	200-234-275	44-69-95
Increase	58-113	12-30	17-43	17-30	36-73	15-30	71-158	34-75	25-51

1/ Read SMY figures under each column from left to right for FY '66, '72, and '77, respectively.
2/ See Page 108 for list of Research Problem Area titles.

Table 5. (Cont'd)

RPA No. 2/	INDIVIDUAL POLLUTANTS OR SUBJECT AREAS 1/						
	PESTICIDES	RADIO ACTIVE SUBSTANCES	AIRBORNE CHEMICALS & PARTICULATES	NOISE	SOCIO-ECONOMIC ASPECTS	SYSTEMS ANALYSIS	TOTAL
101			3-5-7				3-5-7
102							20-28-36
103							26-36-46
104					0-2-5		0-2-5
105			15-18-20				30-40-49
106							30-10-18
107			5-7-10				91-154-226
108					2-5-7		2-5-7
111		0-2-2					5-9-12
201	100-100-100						100-100-100
203	68-68-68						68-68-68
204	200-200-200						200-200-200
205	162-162-162						162-162-162
206	40-40-40						56-58-60
207	376-376-376						376-376-376
208	184-184-184						184-184-184
209	105-105-105						150-151-152
210	78-78-78						78-78-78
211	202-202-202						202-202-202
212	51-51-51						51-51-51
213	49-49-49	0-1-1					49-50-50
214			8-20-40	1-3-5			9-23-45
303					0-2-5		0-2-5
304							50-52-55
306							0-5-5
307		0-1-1					90-94-96
309							0-2-5
313							12-25-42
315							30-35-45
401				0-0-2			0-2-7
403							0-5-15
406							0-5-15
410							0-2-5
701	118-118-118						118-118-118
702							60-80-100
706							50-51-52
707							16-18-25
901	10-15-20	0-3-6	10-20-37		0-5-10	2-4-6	112-257-410
908					0-2-5		0-2-5
TOTAL	1743-1748-1753	0-7-10	41-70-114	1-3-7	2-16-32	2-4-6	2403-2747-3139
Increase	5-10	7-10	29-73	2-6	14-30	2-4	344-736

1/ Read SMY figures under each column from left to right for FY's '66, '72, and '77, respectively.
2/ See Page 108 for list of Research Problem Area titles.

Research Problem Areas Involving Pollution or Pollution-Related Research

No.	Title
101	Appraisal of soil resources
102	Soil structure; and soil, plant, water, nutrient relationships
103	Management of salinity and saline soils
104	Alternative uses of land
105	Conservation and efficient use of water
106	Efficient drainage and irrigation systems and facilities
107	Technology of watershed conservation and management
108	Economic and legal problems in management of water and watersheds
111	Timber management
201	Control of forest insects
202	Control of diseases of forest trees
203	Prevention and control of forest fires
204	Control of insect pests of fruit and vegetable crops
205	Control of diseases of fruit and vegetable crops
206	Control of weeds and other hazards of fruit and vegetable crops
207	Control of insect pests of field crops
208	Control of diseases of field crops
209	Control of weeds and other hazards of field crops
210	Control of insect pests of livestock and poultry
211	Control of diseases of livestock and poultry
212	Control of internal parasites of livestock and poultry
213	Protect livestock and poultry from toxic chemicals, poisonous plants, and other hazards
214	Protection of plants and animals from harmful effects of air pollution
303	Economics of timber production
304	Improvement of biological efficiency of fruit and vegetable crops
306	Systems analysis in production of fruits and vegetables
307	Improvement of biological efficiency of field crops
309	Systems analysis in production of field crops
313	Improved livestock and poultry production and management systems
315	Improvement of general purpose farm supplies, equipment, and buildings
401	New and improved forest products
403	New and improved fruit and vegetable products
406	New and improved food products from field crops
410	New and improved meat, milk, and egg products
701	Insure food products free from toxic residues from agricultural sources
702	Protect food supplies from harmful micro-organisms and naturally occurring toxins
706	Control of insect pests of man and his belongings
707	Prevent transmission of animal diseases and parasites to people
901	Alleviate soil,water,and air pollution
908	Improvement of rural community institutions and services

FACILITIES

The Long Range Study projection of 334 additional SMY's for RPA's 214 and 901 by 1977 would require about 300,000 square feet of office and laboratory space, much of it new. Proportional amounts will be required for RPA's projected for pollution or pollution-related SMY's projected by this Task Force under other RPA's. Additional greenhouse space and animal shelters may be needed. In addition, many small, frequently temporary experimental waste management facilities will be required.

The Task Force recommends that a substantial number of SAES and Forestry Schools establish pollution research groups with adequate facilities so that research may be responsive to needs of various areas. Such groups are also needed for graduate training in pollution research. Some USDA research scientists should be located with such groups so that they too may participate in graduate training.

The Task Force further recommends the establishment or expansion of national or regional research centers. The SMY's now engaged in pollution research under RPA's 214 and 901 are fairly evenly distributed among the four SAES regions. In 1966 there were in the Southern AES 16.3 SMY's, in the Northeastern 16.1, in the North Central 16.2, and in the Western 21.0. While all regions, indeed all States, probably need to do some research on pollution problems of greatest local concern, there are and should be some laboratories, both USDA and State, with five or more SMY's engaged in pollution research. New Jersey, California, and Oregon each reported more than five SMY's under RPA's 214 and 901 in 1966; in addition to Beltsville, ARS reported more than five SMY's in North Dakota and Washington. The new ARS Water Management Laboratory at Durant, Oklahoma, is expected to have ten SMY's engaged in pollution research by 1970. Texas and Michigan have reported building plans which include facilities for pollution research.

It is particularly recommended that an animal waste management research center be established. Such a center should provide space and facilities for 10 to 20 SMY's in several disciplines.

Except for unique local or State research needs, it is recommended that significant expansion in pollution research be planned primarily at those locations which now have significant programs under way and/or which have or expect to have the facilities and supporting talent to provide an efficient and productive research program.

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